THE DEVILLE (DETRITAL) FORMATION OF THE KINDERSLEY AREA, SASKATCHEWAN

by

D. R. BRODIE

The Department of Geology, University of Alberta, considers that this thesis represents a contribution to the science of geology of considerable merit. The findings expressed in this thesis are not necessarily the views of the members of the Department of Geology.

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The undersigned hereby certify that they have read and recommend to the School of Graduate Studies for acceptance, a thesis entitled The Deville (Detrital) Formation of the Kindersley area, Saskatchewan, submitted by David R. Brodie BSc., in partial fulfillment of the requirements for the degree of Master of Science.

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ABSTRACT

The Deville formation in the Kindersley area of Saskatchewan is, for the greater part, composed of a weathered residue developed on the underlying Mississippian limestones, sandstones and shales. A small part of the sediments in this formation may have been derived from the Jurassic rocks which occur in the southern part of the map-area.

The Deville formation can be divided into three major lithologic groups. The first of these is thought to represent an original soil profile formed on the Mississippian surface. This group is composed of vari-coloured, waxy kaolin-illite clays in which are embedded white, angular, fresh to weathered chert fragments up to 2 inches or larger in diameter and traces of fine to very fine grains of quartz. Rocks of this type are probably not continuous over the entire map-area due to subsequent reworking, but where present they lie directly on the Mississippian. On areas of high relief on the Mississippian erosion surface they comprise the entire Deville section and are overlain by Blairmore sediments.

The second group is composed of chert fragments with traces of clear, rounded to sub-rounded, fine quartz grains embedded in a powdery, kaolin-illite matrix. This group was probably formed by the reworking of the above described soil profile. Rocks of this type are believed to occur in areas of lowest relief on the Mississippian erosion surface, and therefore lie on the first

described group where present, or directly on the Mississippian sediments.

The third major group is probably the result of reworking of the two groups described above, by an incoming lake or sea. Lithologically this group is made up of clear, rounded to sub-rounded, fine to very fine quartz grains embedded in a powdery, kaolin-illite matrix. In section rocks of this type have been found to overlie the above two groups, in a position of intermediate relief on the Mississippian surface. Oil accumulations in the Deville formation, in general occur in this lithologic group.

Due to reworking, lenses of the first described group are commonly found throughout the remainder of the formation.

UNIVERSITY OF ALBERTA

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CHAPTER 1

General Statement

To the writer's knowledge, no previous work has dealt fully with the Deville formation on the Western plains. Consequently, the chief purpose of this paper is to describe the stratigraphy and to outline as far as possible the lithofacies found within the Deville formation of the Kindersley area. In addition to this, an attempt will be made to denote areas of possible commercial oil accumulation within the formation.

Location

The Kindersley area considered in this thesis extends from township 22 north to township 30, and from range 19 to range 29, west of the Third Meridian. The location of the area is shown on plate 1.

Previous Work

Several papers have been published on the Kindersley area, none of which deal directly with the Deville formation. Geological reports which deal mainly with later Mesozoic sediments, have been published by Warren (1930), Fraser et al (1935), and Wickenden (1945). Reports by Harvie (1952), Hamilton (1952), and Berg (1953) deal with the Mississippian system and are pertinent to the study of the Deville.

Reasoner and Hunt (1954), make mention of the Deville formation in a report on the structure and stratigraphy of the Coleville-Buffalo Coulee area of Saskatchewan.

PLATE I

INDEX MAP

D.R. BRODIE

P.C. Badgley (1952) in a description of the stratigraphy of the lower Cretaceous in Central Alberta introduced the term Deville formation for the erosional debris (previously known as the Detrital zone), overlying the Paleozoic erosional surface. The term Deville is also applicable to the "detrital" zone of the Kindersley area.

Descriptions of the stratigraphy and insoluble residues of the Madison group of Montana were published by Sloss and Hamblin (1942); their findings are useful in the study of the Deville in the Kindersley area.

Present Study

The present study involved the logging of Deville well cuttings from 33 wells, a study of electric logs from 61 wells and an examination of Deville cores from 21 wells. Cores of Lodgepole limestone from two wells, were analysed for percentage and character of the residue content. The electric logs, well cuttings, and cores examined are listed in appendix A. Examination of cores was generally restricted to binocular and mechanical analysis. Due to the unconsolidated nature of the various rock types making up the Deville formation, the preparation of thin sections was generally impossible.

Cores were obtained from the Saskatchewan Geological Survey at Regina, Saskatchewan. Samples and electric logs were

obtained from Husky Oil and Refining Limited, Calgary.

CHAPTER 11

LITHOLOGY OF THE DEVILLE FORMATION

General Statement

The term, Deville formation, was introduced by Badgley (1952) from the Imperial Deville #1 well (Lsd.9,S.36,T.51,R.20W4), in which it occurs at depths of 3,555.5 to 3,605 feet and is underlain by Paleozoic rocks. Prior to this the formation was known as the Detrital zone. The Deville from the above well comprises rocks of the following types in order of decreasing abundance: "greenish grey, waxy shale; greenish grey, silty shales; greenish grey, shaley siltstones; greyish green, argillaceous, quartzose sandstones; and dark reddish brown shales and silty shales. Siderite nodules are commonly embedded in the shales", Badgley (1952).

In the Kindersley area, the Detrital zone is comparable both in lithologic character and in stratigraphic position to the Deville formation as described by Badgley. It is the writer's opinion that the term Deville should be adopted for the Detrital zone in the Kindersley area. Previous reports on the area with the exception of Berg (1953), have referred to the formation concerned as the Detrital zone.

The relative position of the Deville formation in the stratigraphic section found at Kindersley is shown in table 1.

Major Lithologic Units

The Deville formation can be divided into three major lithologic groups, with minor variations within each group.

TABLE 1

Stratigraphic Column, Kindersley Area*

Era	Period	Epoch	Group		Formation
Mesozoic	Cretaceous	Upper	Montana		Bearpaw
					Old man
					Foremost
					Lea Park
			Colorado	Upper	First Specks
					Second Specks
		?			Fish Scale Zone
		Lower		Lower	
					Viking
					Blairmore
					Deville (Detrital)
	Jurassic	Middle	Ellis		Shaunavon
					Gravelbourg
					Watrous ? Anhydrite
Paleozoic	Mississippian	Lower	Madison		Lodgepole
					Inglenook Member
				Bakken	Buffalo Coulee Mbr.
					Coleville Member
					Kindersley Member
					Cabri Member
	Devonian	Upper	Qu'Appelle		Three Forks
			Saskatchewan		"Nisku"
					Duperow
			Beaverhill Lake		Souris River
					Dawson Bay
		Middle & Lower	Elk Point		Winnipegosis / Prairie Evaporite
					Ashern
	Silurian				
	Cambro-Ordov.				
Precambrian					

* A.A.P.G. Nomenclature-1953

<u>Group 1:</u> This group consists of waxy, vari-coloured, kaolinitic and illitic clays in varying proportions, in which are embedded chert fragments and clear, rounded to sub-rounded, very fine quartz grains. Orange to brown spherulites of siderite are commonly found throughout the clay. For convenience this rock type will be referred to as the Deville "shale".

In colour, the clays are most commonly light grey, grey-green, and green, although dark grey and brown have been observed in some cores. The latter colours are probably due to various mixtures of illite and kaolin or the presence of organic matter or the presence of ferruginous material. Identification of the clay material was made by the Research Council of Alberta, using x-ray techniques. The following clay types were identified:

1. Three samples of grey, waxy shale from H.P. Glidden #1, H.P. Madison #1 and Roy. Crystal #1 at 2702, 2808 and 2631 feet respectively, were identified as predominantly kaolin with traces of illite.

2. One sample of grey, waxy shale from H.P. Madison #1 at 2869 feet, and one sample of dull brown shale from P.H. Alsask #1 at 2660 feet were identified as approximately equal amounts of kaolin and illite.

3. One sample of green, waxy shale from Imp. Netherhill #11-17 at 2915 feet was identified as predominantly illite.

The "d" spacings and relative intensities (R.I.) from which these identifications were made are shown in table 2. Relative intensities are based on a scale ranging from barely

visible (B.V.) to visable (V.) to 10 which is designated for the strongest line on the film; "d" spacings are expressed in angstrom units.

TABLE 2

1			2			3		
"d"A°	R.I.	MINERAL	"d"A°	R.I.	MINERAL	"d"A°	R.I.	MINERAL
10.08	V	Illite & Kaolin	10.36	1.5	Illite	9.933	V	Illite
7.147	4	Kaolin	7.356	1.5	Kaolin	4.492	1.5	Illite
4.417	3.5	"Clay"	4.539	3	Illite & Kaolin	3.099	1	Illite & ?
3.878	1	Kaolin	3.599	V	Kaolin	2.920	V	Illite & ?
3.591	3	Kaolin	3.016	V	Calcite	2.587	1.5	Illite
2.80	3.5	Siderite	2.572	3	Illite & Kaolin	2.017	B.V.	Illite
2.57	1.5	"Clay"	2.389	.5	Kaolin	1.504	V	Illite
2.501	1	Kaolin	2.352	.5	Kaolin ?			
2.347	2	Siderite	1.508	.5	Illite & Kaolin			
2.245	1	Kaolin	1.493	.5	Kaolin			
1.738	1.5	Siderite						
1.494	2	"Clay"						

Note: Quartz spacings have been omitted (Quartz 3.35 A° = R.I. of 10)

Chert fragments found in the Deville "shales" are characteristically milk white and angular. Soluble products originally present in the chert have been leached with the subsequent formation of vein-like porosity. Individual fragments range from fine sand size up to three inches or larger in diameter,

but commonly occur between one eighth and one half inch in size. Generally the chert is stable, however in several cores it has broken down to a soft material not unlike kaolin which retains the shape of the original fragment. Occasionally fragments are observed with an unaltered centre surrounded by a weathered chert auriole. Chertified fossil remains (crinoid stems, sponge spicules, corals and brachiopods) are found throughout the Deville "shale".

Although quartz grains form only a minor constituent of this group, locally they may make up a considerable portion of the rock. An unsuccessful attempt was made to separate heavy minerals from the rocks in this group.

Group 11: Lithologically this type differs little from group 1, in that it consists of milk-white, angular chert fragments embedded in a white kaolin-illite matrix. The matrix however is generally quite powdery and poorly consolidated. Locally considerable amounts of very fine to fine quartz grains occur. Chert concentration appears to be more abundant in this group than in the Deville "shales". For convenience this group will be referred to as the Deville "conglomerates".

Chert and quartz fragments found in this group are identical in size, angularity, and colour to those found in group 1. Upon weathering the chert fragments form a residue not unlike the waxy kaolin as found in the first described group. Some cores have been observed in which the leached veins in the chert have been filled by secondary calcite.

X-ray data for identification of the clay matrix in this group is not available.

Group 111: This group is composed of clear, rounded to sub-rounded, fine to very fine quartz grains embedded in a white, powdery, flour-like kaolin-illite matrix. Fine grained angular chert is common in the upper part of this group. In the lower part the chert size increases up to ½ inch in diameter. Brown spherulites of siderite .2 to .5 mm. in diameter are commonly observed in rocks of this type. Locally the sand and chert grains have small amounts of matrix material and consequently are semi to unconsolidated. For convenience this group will be referred to as the Deville "sands".

To determine the size of the quartz grains, a mechanical analysis was conducted on Deville "sand" from H.P. Eatonia #B-2 at a depth of 2860 feet; the results are shown in table 3.

TABLE 3

Weight of Sand	Size Range In mm.	Weight Recovered	Remarks
112.5 gms.	1.41 - 1.000	5.6 gms.	Clusters of smaller quartz grains
	1.00 - 0.350	4.8 gms.	As above with trace of med. gr. qtz.
	0.35 - 0.149	41.5 gms.	Fine grain quartz
	0.149- 0.074	58.5 gms.	Very fine grain quartz
	0.074- 0.062	2.0 gms.	Silt size quartz

Binocular examination of the remainder of cores from the Deville "sands" indicates that the bulk of the quartz grains fall within the above size ranges. Secondary iron oxide

and iron carbonate deposits are occasionally seen in the Deville "sands".

Accessory heavy minerals found in the Deville "sand" in order of decreasing abundance are, opaques, tourmaline, zircon, staurolite, rutile and traces of muscovite.

Siderite Spherulites

Spherulites of siderite are found to occur in varying amounts (as high as 25%) within the three major rock types of the Deville formation and in the lower Blairmore sediments. Characteristically they are brown, round particles ranging in size from .2 to .5 mm. in diameter. Due to their relative instability it is probable that they were formed as secondary deposition products from iron carbonate rich solutions, rather than as residual material derived from pre-existing sediments. Very fine quartz grains , which are often found included within individual spherulites, probably acted as nuclei for deposition. Identification was made by x-ray and the data interpreted as shown in table 4.

Minor Rock Types

In addition to the three major groups outlined above, rock types which occur in very minor amounts have been observed. Usually these minor types can be attributed to secondary deposition or alterations within pre-existing sediments.

In H.P. Eatonia #A-2, P.H. Josephine #1 and H.I. Pinkham #1 , at depths of 2,884, 2,967 and 2,942 feet respectively, thin zones of small chert fragments, fossil remains and siderite spherulites are seen to occur, cemented in calcareous matrix.

TABLE 4

"d" A°	R.I.	Identification
3.59	5	Siderite
2.79	10	Siderite
2.34	4	Siderite
2.13	4	Siderite
1.962	4	Siderite
1.732	10	Siderite
1.507	1	Siderite
1.426	1	Siderite
1.355	1	Siderite
1.199	0.5	Siderite
1.081	V	Siderite

Note: Quartz spacings have been omitted.

A core of massive, very fine grain siderite three inches in length was observed from H.P. Eatonia #A-2 at a depth of 2,897 feet.

From the upper part of the Deville formation in the Tide. Plato Crown #1 well, a thin section of dark grey carb-onaceous shale was observed.

CHAPTER 111

ORIGIN OF THE DEVILLE FORMATION

Geologic History of the Area

As it is thought that the Deville formation is in the main, made up of insoluble residues derived by weathering from pre-existing sediments, it is necessary to attempt to reconstruct the geologic section as found in the Kindersley area prior to exposure and weathering, and to determine what part these sediments had in the development of the Deville.

The chief problem is that only an approximation can be made as to the total areal extent of the sea in Mississippian time. It is known that the Kindersley area was inundated during early Mississippian time when the Bakken and Lodgepole formations were deposited. Sloss and Hamblin (1942) in a report on the Montana area indicate, "The Madison sea probably reached its greatest extent in Mission Canyon time." From this it is apparent that the Mission Canyon sea was present in the Kindersley area, and the sediments being deposited were closely allied in nature to those deposited in Montana. Taking the thickness of the Madison section on the Montana-Saskatchewan border (120 miles south of Kindersley) where the Madison is overlain by the Big Snowy group, and projecting it to the Kindersley block, an estimated maximum thickness of 960 feet could be given for the original Madison section at Kindersley.

Following deposition of the Mission Canyon limestones in Montana, Sloss and Hamblin (1942) report, "The sea withdrew to

the center of the depositional basin where evaporite beds transitional to Big Snowy sedimentation appear to have been deposited in a remnant sea. Elsewhere the Mission Canyon limestones were laid bare to solution and subaerial erosion." In dating the first exposure to weathering in the Kindersley block, only a broad estimate can be given. Sloss and Hamblin (1942) indicate the Madison group of Montana to be Kinderhook and Osage in age. Withdrawal of this sea possibly started at an earlier time in the Kindersley area, indicating that weathering would likely start during Osage time.

In Meramac time, the Big Snowy sea in Montana renewed sedimentation above the Madison. This sea may have spread as far north as Kindersley, if so this would break the weathering cycle at this time.

With the possible exception mentioned above weathering continued in Kindersley until Bajocian time when at least parts of the area were again invaded and the Gypsum Springs equivalent was deposited. The original extent of these Jurassic sediments is not known; however since only a short period of exposure followed their deposition it can be inferred that only a thin section if any, was deposited in the northern area.

The area was again subjected to weathering from approximately Oxfordian to Blairmore time. The result of this last cycle would be to remove any Jurassic sediments present in the northern part of the area. A thin section of Jurassic is now found in the southern part of the Kindersley block (see plate 11).

The net result of weathering which is inferred to have started in Osage time, was firstly the complete weathering of any Mission Canyon and Big Snowy equivalent originally present in the area, secondly the weathering of much of the Lodgepole (in places the Lodgepole is completely weathered and the Deville lies directly on the Bakken formation), and thirdly the weathering of Jurassic (if present) in the northern part of the map area.

The inferred sequence of events in the Kindersley area, may be outlined as follows:

1. Local withdrawl of Devonian sea and marked changes in sedimentation (i.e. incoming black shale and sands of the Bakken formation).

2. Spreading of the sea and deposition of argillaceous limestone and local shales of the Lodgepole formation.

3. Maximum spreading of the sea and deposition of Mission Canyon limestone.

4. Withdrawl of the sea from the area in Osage time.

5. Period of weathering and soil formation.

6. Possible marine invasion from the south in Meramac time, with deposition of a thin section of Big Snowy equivalent.

7. Withdrawl of the above sea in Meramac or Chester time and continued weathering to Bajocian time.

8. Invasion by the sea in Bajocian time with possible reworking of the soil profile, and sedimentation in parts of the Kindersley block.

9. Withdrawl of the sea and continued weathering until Blairmore deposition.

10. Further reworking of the soil profile and continental deposition of the Blairmore from the south and southwest.

Insoluble Residues of the Madison Group

If the above geologic history is correct then the Deville formation was derived predominantly from sediments of the Madison group. Prior to discussing the origin of the various lithologic groups found in the Deville, a brief summary will be made of the character of the insoluble residues found in the Madison group.

Sloss and Hamblin (1942), investigated the residues of the Madison group of Montana. It is assumed that the nature of the residues they described, especially those of the Mission Canyon, will generally apply to residues originally present in the Madison group of the Kindersley area.

The samples used by them for determination of residues, were digested in 30%, warm hydrochloric acid. This procedure may have destroyed certain minor features of the residues but should not effect the overall results.

From the descriptions of Sloss and Hamblin (1942) the Mission Canyon in Montana is characterized by small amounts of residue, from a few grains to 2% of the original sample except where massive chert zones are encountered and the residues are as high as 90%. Snow white chert, accessory minerals (magnetite, tourmaline, illmenite, zircon, garnet, biotite and muscovite), and sand grains comprise the bulk of most samples. One persistent zone contains clusters of fine brown quartz crystals; a few zones are found rich in silicified fossils.

In summary, they describe the residues of the Lodgepole as consisting of large amounts of silicified fossil fragments, large amounts of argillaceous matter, and masses of tan and grey chert bearing silicified bryozoans.

The writer conducted insoluble residue analysis of Lodgepole cores from the wells shown in table 5. The residues from these cores were characterized by the following materials; (a) abundance of milk white, angular chert fragments ranging from silt size up to 3 inches in diameter, (b) chertified fossil remains (crinoids, corals, sponge spicules and brachiopods), (c) considerable amounts of clear, sub-rounded to round, very fine quartz grains, (d) unidentifiable grey-brown clay and (e) relatively rare amounts of accessory minerals consisting of opaques, zircon, tourmaline, staurolite and garnet with traces of rutile and muscovite.

TABLE 5

Well	Interval	Weight of Sample	% Residue
P.H. Inglenook #1	2915-2920	627.5 gms.	21%
P.H. Inglenook #1	2940-2945	557.3 gms.	7%
P.H. Inglenook #1	2954-2955	398.0 gms.	95%
P.H. Cabri #1	3100	628.0 gms.	97%
P.H. Cabri #1	3114	710.0 gms.	43%
P.H. Cabri #1	3116	316.5 gms.	8%

The similarity between the above described residues and materials making up the bulk of the Deville formation is readily apparent.

Weathering of the Madison Group

From the preceding discussion on geologic history, it can be assumed that a sizeable section of Lodgepole and Mission Canyon sediments were deposited in the Kindersley area. From Osage time to Bajocian time, with the doubtful exception of inundation and sedimentation by the Big Snowy sea in Chester time, the Madison group was laid bare to weathering processes.

Sloss and Hamblin (1942) have observed weathered sections of the Mission Canyon in northern Montana, where they underly the Big Snowy group. Their report indicates that in these sections, solution action, with the development of Karst topography was the strongest weathering agent at that time.

It is probable that the same type of environment also existed in the Kindersley area, however weathering here continued for a much longer period of time. The end product of surface and sub-surface solution action of this type on the Mission Canyon limestones, would be the complete removal of acid soluble materials and concentration of the insoluble residues on the underlying Lodgepole surface. Further solution and weathering processes, largely due to downward percolating solutions, would act on the residues and on the underlying Lodgepole with the ultimate development of a mature soil profile. Due to the argillaceous nature and consequent impermeability of the Lodgepole, much of the solution action was probably restricted to the upper surface. Locally however sub-surface solutions may have been active.

Residue from any Big Snowy type sediments in the Kindersley area would probably be negligible in amount.

Origin of Deville "Shale" (Group 1)

Evidence indicates that the Deville "shale" is the undisturbed remnants of the soil profile formed during the weathering cycle outlined above. Undoubtedly a certain portion of this original profile has been transported from the area, and as will be seen later much of it has been altered by reworking to other rock types.

The fact that the clay content is largely kaolinitic in nature indicates an acidic environment during weathering, this is substantiated by the fact that acid soluble components are completely missing. The original source of the clay is in all probability directly from the underlying limestone. Attempts were made to identify the clays present in the Lodgepole formation, but apparently the severe acid treatment used to separate the clays from the limestone destroyed their structure to such an extent that identification by x-ray was impossible. Consequently it is not known if these clays were originally kaolin-illite, or if a transformation has taken place during the weathering cycle.

Chert and quartz found in this group were undoubtedly derived from the Madison.

During initial stages of weathering this group probably covered a large part of the map area. In certain localities reworking, transport and possible introduction of foreign material by river action altered the original lithology and eliminated it from classification in this group.

Evidence which would indicate that this group is a remnant soil profile made up of residues from the Madison group can be listed as follows:

1. Lack of bedding

2. Chert fragments, while still retaining original shape have been completely weathered

3. General homogeneous nature of the group

4. Kaolin-illite matrix is waxy, well compacted

5. Similarity between original components of the group to components of insoluble residue found in the Madison

6. It comprises the total section of the Deville in areas of highest relief on the Mississippian erosion surface.

Topography of the Mississippian Erosion Surface

In the discussion of origin of the remaining two groups the terms low relief, high relief and intermediate relief with reference to the Mississippian erosion surface will be used widely. These areas are shown on a topographic map of the erosion surface on plate 11 (in pocket).

In mapping the topography, difficulty was encountered in re-orienting the erosion surface from its present disposition to that which it occupied at the end of the formation of the Deville. Probably the most accurate map (plate 11) is that obtained by plotting the isopach values of the Viking-Erosion Surface interval with the assumption that, a) the Viking top was essentially horizontal at the time of its deposition, and b) there was no appreciable change in the disposition of the erosion surface from the end of the formation of the Deville to the end of Viking deposition. A plot of this nature will effectively show by variations in thickness the relative relief on the erosion surface, however as wells are limited in number only regional elevation trends can be interpreted. Certain minor errors

are undoubtedly present due to local variation in the original Viking top. The electric log picks of the Viking and Mississippian tops used, are tabulated in appendix C.

Two other methods of topographic mapping employed were firstly, plotting the isopach values of the Blairmore-Erosion Surface interval with the assumption that the Blairmore top was horizontal when deposited, and secondly reduction of the present regional tilt of the erosion surface (which is 12 feet per mile to the south) to 0 degrees, however both of these resulting maps proved unreliable.

Origin of Deville "Conglomerates" (Group 11)

Evidence indicates that this rock type is the reworked equivalent of group 1. This inference is based on the following criteria:

1. Powdery, poorly consolidated nature of the kaolin-illite matrix

2. Similar mineral constituents in each group

3. Rocks of this group are located in areas of low relief

4. Relative increase in the amount of chert (i.e. much of kaolin-illite matrix has been carried away)

5. Local sandy lenses within the group

In section, (plate 111-V pocket) the rocks in group 11 are found in areas of low to intermediate relief on the erosion surface. In areas of intermediate relief rocks of group 1 have been observed to underly rocks of this group, indicating that in these areas at least, reworking was restricted to the upper part of the original soil profile. In areas of low relief, it is not known if only the upper

portion or if the entire soil profile has been reworked.

The agents responsible for the reworking of these rocks, may include river action with the development of broad valley systems, invasion of lower areas by a fresh water lake, and invasion of the low areas by an incoming Jurassic sea.

Origin of Deville "Sands" (Group 111)

The sand and chert grains making up the Deville "sands" are characteristically well sorted and rounded, indicating that they have undergone a prolonged period of beach action either in a lacustrine or marine environment. This is substantiated by the presence of a transitional zone often found between Deville "conglomerates" and the Deville "sands"; this zone is marked by an increase in quartz content and decrease in chert size upward.

The fact that the material has undergone a period of beach action limits the source areas to two possibilities, either reworking of the Deville "conglomerates" by lacustrine or marine waters and concentration of sand material in beaches, or transportation of material into the area and concentration of it as in the former case. The large number of chert grains found in the Deville "sands" indicates the source to be, in part at least, from the Deville "conglomerates". A comparison of the heavy minerals found in the Deville "sand" to those in the Mississippian as shown in table 6, show a close similarity, indicating the source of Deville "sands" to be the Madison or from pre-existing Madison residues (i.e. the Deville "conglomerates"). These lines of evidence however are far from conclusive as to the actual source of sand.

TABLE 6

Deville Sand	Lodgepole	Mission Canyon (in Montana) Sloss & Hamblin	Bakken Sand
Tourmaline 47%	Tourmaline 40%	Tourmaline	Tourmaline 87%
Zircon 33%	Zircon 26%	Zircon	Zircon 6%
Staurolite 17%	Staurolite 14%	Garnet	Garnet 4%
Rutile 3%	Calcite 10%	Biotite	Apatite 1%
Muscovite T	Muscovite 4%	Muscovite	Rutile T
Silliminite T	Garnet 4%		Muscovite T
	Rutile T		
	Gypsum 2%		

Note: T denotes less than 1%
The percentages of heavy minerals described by Sloss and Hamblin are not available.

It should be noted that prior to actual separation by tetrabromo ethane the sand samples used for heavy mineral analysis were placed in a 6N HCl or 10N HNO_3 environment for 8 hours. This was done to remove material such as pyrite and iron carbonate which would cause much of the light minerals to settle out with the heavy fraction. This treatment may have destroyed some of the more acid soluble heavy minerals.

CHAPTER 1V

FACIES OF THE DEVILLE FORMATION

Division of the Deville formation into various facies is based primarily on examination of cores, and to a lesser extent on interpretation of electric logs. Well cuttings within the Deville proved to be quite unrepresentative of the actual rock type being drilled. This is because the kaolin-illite matrix, common in the Deville, disperses when exposed to a drilling mud environment. Dispersion is no doubt aided by abrasion from the rotating drill stem. This breakdown of matrix material liberates any clastics which it contains such as quartz grains and chert fragments. As much of this quartz occurs as individual, fine to very fine grains, the bulk of it is lost in passing over the coarse screen on the shale shaker. It is possible then, to drill through a section of Deville sand and recover only traces of representative cuttings.

Since Deville cores have been obtained from only 21 wells in the 3,240 square miles considered in this thesis, it is to be understood that facies interpretations are limited to a regional scale. With further drilling and coring in the Deville, it is likely that refinements will be made in the interpretation of facies changes within the Deville.

Lithologic descriptions of the cores examined are tabulated in appendix B. In order to determine the position these cores occupied in the Deville formation, the reader is referred to appendix C where the electric log picks of the Deville and Mississippian tops are tabulated. Since well cuttings are largely unrepresentative, descriptions

of these will be omitted.

For the vertical representation of facies herein outlined, the reader is referred to plates 111, 1V and V. Locations of these sections are shown on plate 11. Construction of these sections is based on cores and electric logs from the wells shown, but since wells are limited in number assemblage of data is largely inferred. It should be pointed out that the erosion surface is obtained from Viking-Mississippian isopachs, hence the disposition of Mississippian, Deville and Blairmore sediments are as they were following Viking deposition. Plate 11 illustrates the facies of the Deville superimposed on the Mississippian erosion surface.

Since the Deville "shale" has been identified as a paleosol, this group should theoretically be distributed on broad, relatively high, intervalley areas on the erosion surface. This assumption is substantiated by cores from the following wells which consist essentially of Deville shale types (for location see plate 11 or appendix A): 1) P.H. Eastside #1, 2) P.H. Alsask #1, 3) P.H. St. Eloi #1, 4) P.H. St. Florence #1, 5) Roy. Crystal #1 and 6) Imp. Netherhill #10-33.

Electric logs which also indicate this disposition are: 1) P.H. Awde #1, 2) P.H. Marengo #2, 3) P.H. Eyre #1, 4) P.H. Mantario #1, 5) P.H. Flaxcombe #1, 6) P.H. Fairmount #1, 7) P.H. Verendrye #1, 8) P.H. Newburg #2, 9) P.H. Braeburn #1, 10) P.H. Teo #1 and 11) Imp. Netherhill #10-13.

With possible exceptions of local reworking, it is believed that in these high areas, rocks of the Deville "shale" from 50 to 80 feet thick constitute the entire Deville section. Cores and electric

logs indicate that the lower part of these "shales" in the St. Eloi, St. Florence and Crystal wells have a considerably higher quartz content. This may be due to variation in the quartz content in original Mission Canyon and Lodgepole limestones.

On the flanks of the high intervalley areas, Deville "shale" is overlain by rocks of group 11 and group 111. Evidence of this is seen in cores and electric logs from 1) P.H. Glidden #1, 2) Imp. Netherhill #11-17, 3) H.P. Madison #1, 4) H.I. Pinkham #1, 5) P.H. Marengo #1, 6) P.H. Marengo #3 and 7) P.H. Dewar #1.

It is not known how deeply the Deville "shale" extends into the lower areas. It is indicated in plates 111-1V to be continuous across these lower areas, but this can be proved only by further coring in the area.

It is apparent that the overlap or pinch out of groups 11 and 111 over the Deville "shale", must occur in the area between the wells described where the "shale" is overlain by Blairmore and where it is known to be overlain by these groups. The placing of this pinch out is largely inferred, however some evidence for its positioning can be cited in certain areas. The thin section of overlap at P.H. Glidden #1 relative to that found in the Eatonia wells, and the variation in section indicated by electric logs in the Marengo wells, indicates that the pinch out line should be placed near these areas. If it is accepted that groups 11 and 111 have been reworked and concentrated by marine or lacustrine waters, then it seems plausible that the pinch out of these groups should generally occur at the same elevation in the whole area. It is interesting to note that the pinch out at P.H.

Glidden #1 and in the Marengo wells, does occur at the same relative elevation. Placing the pinch out line on the basis of relative elevation in general conforms to known sections, especially on the central and the eastern high areas. In the western area, the pinch out has to be placed transgressively to topographic contours in order to conform to the section found in the Eyre and Mantario wells.

Good cores of Deville "conglomerate" are rare. In most cases the smaller chert fragments and matrix appears to have been lost in coring, and only massive chert fragments about 3 inches in length are recovered. As shown in plates 11-V the Deville "conglomerate" is indicated to extend from the above pinch out into areas of low relief, underlain either by Deville "shale" or by Mississippian sediments. It is expected that in the two low valleys running northwest-southeast that the thickness is much reduced due to removal of matrix material by stream action.

Overlying these rocks in areas of intermediate relief are the Deville "sands", with a transitional zone often found between the two groups. Cores and electric logs from the following wells indicate this disposition of the Deville "sands": 1) P.H. Dewar #1, 2) H.P. Eatonia #A-2, 3) Tide. Imp. Plato Crown #1, 4) H.P. Eatonia #A-1, 5) H.P. Glidden #1, 6) Imp. Netherhill #11-17, 7) H.P. Eatonia #B-2, 8) H.P. Madison #1, 9) H.I. Pinkham #1, 10) Soh. D'Arcy #1, 11) P.H. McMorran #1, 12) P.H. Sandgren #1, 13) P.H. Inglenook #1, 14) P.H. Laporte #1, 15) Sturgeon Smiley #3, 16) Alminex Crystal #1 and 17) P.H. Cuthbert #1.

Maximum observed thickness of the Deville "sand" as found in

the Tide. Plato Crown #1 well is 115 feet. The thickness of the Deville "sand" appears to be quite variable due to irregularities in the Mississippian erosion surface. Since topographic mapping is limited to a regional scale, it is possible that there may be local high areas of sufficient relief to prohibit any accumulation of "sand".

The inferred areas where this "sand" occurs are indicated in plate 11. It is not known how far into the low areas Deville "sand" can occur, nor is it known if the northwest extension of "sand" indicated through the P.H. Kiyiu #1 well is valid.

Lenses of kaolin-illite clay are found throughout the Deville "conglomerate" and "sand" illustrated in plates 111-1V. Undoubtedly the material in these clay lenses has been derived from the Deville "shale" either by stream action off the areas of high relief, or by variations in water level of marine or lacustrine waters present in the low areas.

Well cuttings from P.H. Riverfront #1, P.H. Dungloe #1, P.H. Prelate #1 and P.H. Lemsford #1, indicate the presence of a Deville section between the Jurassic and the Mississippian. Due to the prevalence of chert in the samples this section is predominantly of group 1 or group 11 type. On plates 11-V this section is represented as Deville "shale", but the actual rock types present cannot be determined until the interval is cored. This deposit is probably local in nature and in places may have been completely removed by the incoming Jurassic sea. On plate 11 this Deville section is indicated to be highly local in extent, however further drilling in the area may prove it to be much more widespread.

In the southern part of the map-area the Jurassic escarpment must have had influence on the type of Deville sediments found in the area. Final reworking in this area, probably by an incoming early Blairmore lake, would tend to rework much of the upper Jurassic sands and incorporate them with Deville "sand" on the upper surface of the Jurassic. Consequently this contact is often very difficult to determine, especially in the areas where Deville "sand" lies directly on original Jurassic sands. Due to lack of coring at the Deville-Jurassic contact the exact extent or thickness of the Deville "sand" over the Jurassic is not known.

The total thickness of the Deville formation is quite variable, generally the section is thinnest in areas of high relief where it varies from 40 to 80 feet. In areas of low relief on the erosion surface thicknesses of 100 to 150 feet are common. The thickness of the Deville section in each well is shown in appendix C, where the electric log picks of the Deville and Mississippian tops are tabulated.

Nature of the Contacts

Contacts of the various rock types within the Deville formation appear to be gradational.

In most wells the Blairmore-Deville contact appears to be fairly distinct, although evidence of Deville type sediments, notably quartz grains and kaolin stringers have been observed within the Blairmore, indicating the succession to be somewhat gradational. Where the Blairmore is directly underlain by Deville "shale" or "conglomerate", the contact in well cuttings is marked by the first appearance of white chert fragments in the samples; however where the

Blairmore is underlain by Deville "sands", the contact may not be this distinct due to poor recovery of cuttings. The most definite method of determining the contact in the latter case is by coring into the Deville formation.

Most oil companies working in the area refer to the Deville "sand" as the Basal Blairmore sand. Well rounded quartz grains, the presence of small white chert fragments and the white kaolin-illite matrix suggest such strong affinity to the Deville that there is little doubt that it is part of this formation. Additional evidence for the inclusion of this sand in the Deville formation is the slight contrast seen between heavy minerals of the Deville and those of the Blairmore as shown in table 7. The samples used for these heavy mineral separations were also treated in acid.

Lithologically the Blairmore is typically made up of grey-brown sands and dark shales, providing a sharp contrast to the very light coloured sands and clays of the Deville. In several wells a salt and pepper calcareous sandstone is observed to occur from 0 to 60 feet above the Blairmore-Deville contact.

The Lodgepole-Deville and Bakken-Deville contact is generally sharp, but the Jurassic-Deville contact, as mentioned earlier is sometimes difficult to determine. In the P.H. Alsask #1, P.H. Eyre #1, P.H. Merid #1 and P.H. Mantario #1 wells, in the northwestern part of the area, difficulty is encountered in determining the Lodgepole-Deville boundary. A portion of the electric log from Mantario #1 in Fig. 1, showing the interval in question indicates two limestone beds separated by shale break. This interpretation is substantiated by an

TABLE 7

Deville "Sand"	Blairmore (H.P. Glidden #1 2,690)
Tourmaline 47%	Tourmaline 17%
Zircon 33%	Zircon 35%
Staurolite 17%	Staurolite T
Rutile 3%	Rutile 2%
Muscovite T	Muscovite 1%
Silliminite T	Garnet 45%
	Kyanite T

Note: T denotes less than 1%

examination of samples from the Mantario and Alsask wells, which show an upper and lower white, finely crystalline limestone separated by a dark grey to black shale. It has been interpreted by the writer that the upper limestone member represents the top of the Lodgepole, underlain by a near shore shale facies which is in turn underlain by the Lower limestone member. This same sequence has been found to occur by Berg (1953) in the Inglenook area. He referred to this middle shale as the Inglenook member of the Lodgepole formation.

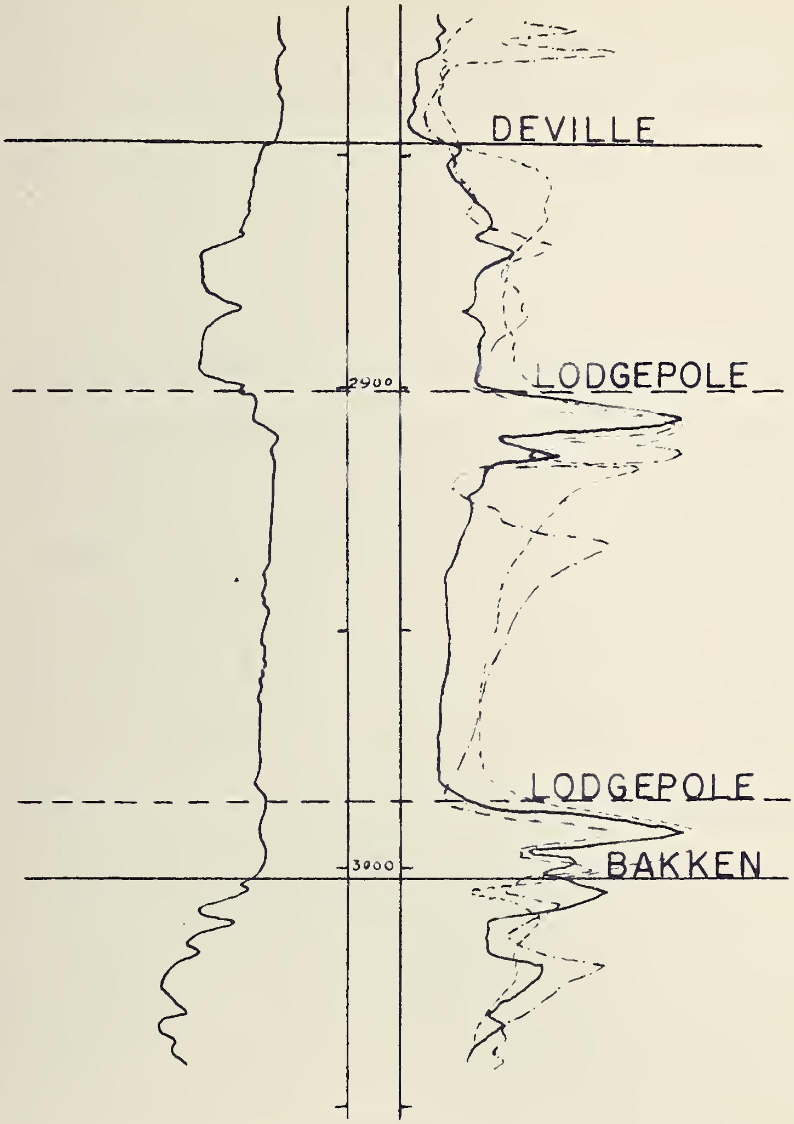

Fig.1 PORTION OF E-LOG ON
P.H. MANTARIO I

CHAPTER V

OIL ACCUMULATION IN THE DEVILLE FORMATION

Present Production

A survey of drill stem tests conducted in the Deville formation indicates that oil accumulation in the Deville formation is essentially limited to the Deville "sands". The results of these tests are tabulated in appendix D, together with the known or inferred rock types of the interval tested. To establish the relative position of these tests within the Deville formation, the reader is referred to appendix C where the electric log picks of the Deville and Mississippian tops are tabulated. Three wells are presently capable of production from the Deville "sand", namely H.P. Eatonia #B-1, P.H. Hoosier #1 and H.P. Hoosier #2 (the latter two wells are located two miles north of the map-area, in T.31,R.28W3). Production potential from these wells varies from 10 to 40 barrels of heavy oil (gravity 11° - 16° A.P.I.) per day. Bottom sediments and water content varies from 0.1% to 12%. Gas content is generally low, ranging from nil to 3 Mcf. per day. In addition to these commercial oil accumulations, oil recovery has been obtained in drill stem tests of Deville "sand" in P.H. Dewar #1, H.P. Dewar #15-34, H.I. Pinkham #1, H.P. Glidden #1 and H.P. Eatonia #1.

Although cores are not available from P.H. Marengo #1, it is believed from electric log and well-cutting examinations that production in this well is from sandy Deville "conglomerate". Other wells which have yielded evidence of oil within the Deville "conglomerate" are H.I. Pinkham #1 and P.H. Josephine #1.

No commercial production is presently obtained from the Deville "shale", although evidence of oil accumulations has been noted in drill stem tests of the sandy Deville "shale" in P.H. St. Eloi #1 and the Roy. Crystal #1 wells.

Porosity and Permeability of the Deville Formation

Cores of oil saturated Deville "sand" have been observed from P.H. Dewar #1 and H.P. Eatonia #B-1. These sands are in a semi to unconsolidated state; that is the kaolin-illite matrix appears to have been replaced by heavy oil. In these cores intergranular porosity and permeability values are high. It is probable that this absence of matrix material is primarily due to depositional conditions. Dispersion and removal of matrix by migrating fluids may also account for some of the porosity noted above. In attempting to determine the effect oil has on the matrix material, cores of Deville "sand" free of oil staining were immersed in 30 S.A.E. oil for a period of 48 hours. It was found that only the outer portion of the cores (about 1 mm. thick) was permeated by the oil, indicating that dispersion of the kaolin-illite matrix does not take place in an oil environment, at least in this short period of time. It is possible however that under higher conditions of pressure over a longer period of time, migrating oil may disperse the matrix material sufficiently to develop the high values of intergranular porosity and permeability observed in the oil saturated cores. Fresh waters migrating through these "sands" prior to the invasion of oil, could effectively disperse and remove much of the kaolin-illite matrix.

Porosity in the Deville "conglomerate" is due to two factors,

firstly, the absence of matrix material as above but to a lesser extent and secondly, vein-like porosity in chert fragments formed by the leaching and removal of acid soluble material originally present in the chert.

Recommendations

As mentioned previously, the results of drill stem tests indicate that the Deville "sand" is chief reservoir rock of the Deville formation. It is believed that this "sand" occurs as an up dip pinch out over the Deville "shale", consequently it is structurally suitable for the accumulation of oil (plates 11-V).

If the exploitation of heavy oil from the Deville formation is considered to be economically feasible, it is suggested that further exploration be continued in the Deville "sand" near the pinch out boundary indicated on Plate 11 (the recommended areas are coloured green). It is interesting to note that oil shows have been recovered from Deville "sand" in drill stem tests of P.H. Dewar #1, H.P. Dewar #15-34, H.P. Eatonia #B-1, H.P. Glidden #1, H.P. Eatonia #1 and H.I. Pinkham #1. All these wells are located near the indicated pinch out of the Deville "sand".

If the porosity in the Deville "sands" can be attributed to depositional conditions, only local porous zones will be present in the area recommended for exploration. It is suggested then, that exploration first be conducted near areas of known oil accumulation and porosity such as the Marengo, Eatonia, Hoosier or Dewar areas. Due to variations in relief on the underlying erosion surface thickness of oil sand in these areas may be quite variable. This is particularly

noticeable in the Eatonia area where sand thickness varies from neglibible amounts in the H.I. Pinkham #1 well, to 56' in the H.P. Eatonia #B-2 well.

Since well-cuttings of the Deville formation are largely unrepresentative it is recommended that the upper portion, at least, of the Deville be cored in all future wells, in order to indicate firstly, the actual rock type being drilled, secondly the porosity present and thirdly the degree of oil saturation present. This will notonly aid the well-site geologist in determing oil zones and intervals worthy of drill stem tests, but will provide further reliable geologic information about the Deville formation. If coring is not carried out in the Deville formation, it is suggested that samples be collected by the geologist before they pass over the shale shaker screen. These samples should be washed in a pail rather than in a screen box.

Due to the low gravity of oil found in the Deville formation, it is probable that oil recovery in drill stem tests is not too valid a basis in the evaluation of production capabilities. This is born out in the H.P. Eatonia #B-1 well which has a production potential of 30 barrels of oil per day from Deville "sand", yet a 60 minute drill stem test of the interval yielded only 120' of oil and gas cut mud. Although it will not completely solve the problem, it is suggested that drill stem tests conducted for a minimum of two hours will yield a more valid recovery than the one hour test.

SUMMATION

The Deville formation in the Kindersley area consists predominantly of the insoluble residues of the Madison group. Concentration of these residues has been effected by a lengthy period of weathering on the Madison surface, during which time all acid soluble materials were completely removed by a solution action.

On the basis of reworking, these residues can be divided into three major groups differing both in lithology and in stratigraphic disposition. The first of these groups, the Deville "shales", consists of residues which have not undergone reworking. These are found typically on broad areas of high relief on the Mississippian weathering surface. The second group, the Deville "conglomerates", is made up of residues which have undergone only partial reworking, that is sorting of the material is not complete. Residues of this type are generally found in areas of low to intermediate relief on the weathering surface. The third group, the Deville "sands", are made up of residues (and possibly some material which has been introduced into the area) which have been completely reworked and sorted. Deposits of this type are found in areas of intermediate relief.

Oil production at present is largely obtained from the Deville "sands". It is recommended that further exploration be conducted in the Deville "sand" in the areas where it pinches out over the Deville "shale" (see plate 11).

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APPENDIX A

Cores Examined

WELL	INTERVAL (In Deville)
P.H. St. Florence #1 (12,29,30,24 W3)	2575 - 2593
P.H. St. Eloi #1 (13,28,30,23, W3)	2630 - 2640
Imp. Netherhill #10-33 (10,33,28,21 W3)	2912 - 2917 2962 - 2974
Imp. Netherhill #11-17 (11,17,27,21 W3)	2775 - 2841 2910 - 2915
P.H. Dewar #1 (8,29,30,26 W3)	2717 - 2744
Roy. Crystal #1 (10,33,30,24 W3)	2631 - 2636
P.H. Cuthbert #1 (6,2,26,29 W3)	3264 - 3274
H.P. Madison #1 (4,29,26,22 W3)	2798 - 2814 2867 - 2872
P.H. Glidden #1 (7,14,27,24 W3)	2670 - 2715
P.H. Eastside #1 (13,14,29,29 W3)	2750 - 2756
H.P. Eatonia #A-1 (4,29,26,24 W3)	2900 - 2930
P.H. Laporte #1 (16,29,26,25 W3)	3002 - 3006
P.H. Cabri #1 (1,23,24,28 W3)	3014 - 3019
P.H. Alsask #1 (10,7,28,28 W3)	2659 - 2662
H.I. Pinkham #1 (1,31,26,24 W3)	2918 - 2966
H.P. Eatonia #A-2 (9,29,26,24 W3)	2871 - 2919
H.P. Eatonia #B-2 (14,4,27,24 W3)	2847 - 2908
P.H. Josephine #1 (1,23,24,29 W3)	2967 - 2975
H.P. Eatonia #B-1 (2,4,27,24 W3)	2867 - 2879
Tide. Imp. Plato Crown #1 (9,22,24,19 W3)	2660 - 2818
	(Mississippian Group)
P.H. Cabri #1 (1,23,24,28 W3)	3109 - 3119 3250 - 3252
P.H. Inglenook #1 (1,4,28,22 W3)	2915 - 2955

Well Cuttings Examined

WELL	INTERVAL
P.H. Glidden #1 (7,14,27,24 W3)	2600 - 2830
H.P. Eatonia #B-1 (2,4,27,24 W3)	2800 - 2875
H.P. Eatonia #B-2 (14,4,27,24 W3)	2800 - 2950
P.H. Mantario #1 (1,5,27,27 W3)	2800 - 3000
P.H. McMorran #1 (6,11,28,20 W3)	2700 - 3000
H.P. Brock #1 (14,29,28,20 W3)	2700 - 2900
P.H. Newburg #2 (10,11,28,21 W3)	2700 - 2922
P.H. Inglenook #1 (1,4,28,22 W3)	2800 - 3000
P.H. Fairmount #1 (8,19,28,24 W3)	2600 - 2800
P.H. Merid #1 (4,19,28,28 W3)	2600 - 2800
P.H. Netherhill #1 (7,28,29,20 W3)	2500 - 2800
P.H. Fláxcombe #1 (8,10,29,26 W3)	2800 - 3000
P.H. Kiyiu #1 (13,11,30,22 W3)	2600 - 2960
P.H. Ste. Eloi #1 (13,28,30,23 W3)	2500 - 2700
P.H. Teo #1 (2,28,30,25 W3)	2500 - 2800
P.H. Verendrye #1 (1,19,28,23 W3)	2600 - 2750
H.P. Marengo #2 (10,27,28,27 W3)	2850 - 2950
P.H. Alsask #1 (10,7,28,28 W3)	2616 - 2750
P.H. Eastside #1 (13,14,29,29 W3)	2662 - 2820
H.P. St. Florence #1 (12,29,30,24 W3)	2500 - 2700
P.H. Dewar #1 (8,29,30,26 W3)	2600 - 2900
H.P. Dewar #15-34 (15,34,30,26 W3)	2700 - 2800
P.H. Fairdale #1 (8,29,23,20 W3)	2600 - 2800
P.H. Riverfront #1 (1,29,23,22 W3)	2900 - 3100

Well Cuttings Examined (cont'd.)

WELL	INTERVAL
P.H. Sceptre #1 (1,22,23,24 W3)	2600 - 2800
P.H. Leader #1 (13,11,23,26 W3)	2600 - 2700
P.H. Coombe #1 (16,21,23,28 W3)	3000 - 3100
P.H. Josephine #1 (1,23,24,29 W3)	2800 - 3100
P.H. Madison #1 (4,29,26,22 W3)	2700 - 2900
H.P. Eatonia #1 (14,32,26,24 W3)	2900 - 3100
H.P. Eatonia #A-1 (4,29,26,24 W3)	2800 - 2920
H.P. Eatonia #A-2 (9,29,26,24 W3)	2800 - 2970
P.H. Laporte #1 (16,29,26,25 W3)	2900 - 3200

Electric Logs Examined

WELL	LSD.	SEC.	TWP.	RGE.	
P.H. Cuthbert #1	6	2	26	29	W3
Imp. Netherhill #11-17	11	17	27	21	W3
P.H. Glidden #1	7	14	27	24	W3
H.P. Eatonia #B-1	2	4	27	24	W3
H.P. Eatonia #B-2	14	4	27	24	W3
P.H. Mantario #1	1	5	27	27	W3
Socony Sohio D'Arcy #1	NE	22	28	19	W3
P.H. McMorran #1	6	11	28	20	W3
H.P. Brock #1	14	29	28	20	W3
P.H. Newburg #2	10	11	28	21	W3
Imp. Netherhill #10-33	10	33	28	21	W3
P.H. Inglenook #1	1	4	28	22	W3

Electric Logs Examined (cont'd.)

WELL	LSD.	SEC.	TWP.	RGE.	
P.H. Fairmount #1	8	19	28	24	W3
P.H. Merid #1	4	19	28	28	W3
Imp. Netherhill #10-13	10	13	29	20	W3
P.H. Netherhill #1	7	28	29	20	W3
P.H. Flaxcombe #1	8	10	29	26	W3
P.H. Kiyiu #1	13	11	30	22	W3
P.H. St. Eloi #1	13	28	30	23	W3
P.H. Awde #1	4	11	30	24	W3
Roy. Crystal #1	10	33	30	24	W3
P.H. Teo #1	2	28	30	25	W3
P.H. Lemsford #1	8	10	23	23	W3
P.H. Prelate #1	4	13	23	25	W3
P.H. Dungloe #1	8	35	23	25	W3
P.H. Westerham #1	4	12	23	27	W3
P.H. Cabri #1	1	23	24	28	W3
P.H. Eston #1	7	29	25	20	W3
P.H. Normac #1	6	29	25	22	W3
P.H. Sandgren #1	7	29	27	22	W3
P.H. Pinkham #1	10	33	27	25	W3
P.H. Eyre #1	6	10	27	27	W3
P.H. Verendrye #1	1	19	28	23	W3
P.H. Marengo #1	10	26	28	27	W3
H.P. Marengo #2	10	27	28	27	W3
H.P. Marengo #3	10	25	28	27	W3

Electric Logs Examined (cont'd.)

WELL	LSD.	SEC.	TWP.	RGE.	
P.H. Alsask #1	10	7	28	28	W3
P.H. Eastside #1	13	14	29	29	W3
P.H. Braeburn #1	2	32	30	20	W3
H.P. St. Florence #1	12	29	30	24	W3
P.H. Ryerson #1	4	11	30	25	W3
P.H. Dewar #1	8	29	30	26	W3
Sturg. Assoc. Smiley #3	11	31	30	26	W3
H.P. Dewar #15-34	15	34	30	26	W3
Alminex Crystal #4-15	4	15	30	27	W3
Alminex Crystal #7-19	7	19	30	27	W3
Alminex Crystal #6-27	6	27	30	27	W3
P.H. Fairdale #1	8	29	23	20	W3
P.H. Riverfront #1	1	29	23	22	W3
P.H. Sceptre #1	1	22	23	24	W3
P.H. Leader #1	13	11	23	26	W3
P.H. Coombe #1	16	21	23	28	W3
Tide. Imp. Plato #1	9	22	24	19	W3
P.H. Josephine #1	1	23	24	29	W3
P.H. Madison #1	4	29	26	22	W3
H.P. Eatonia #1	14	32	26	24	W3
H.P. Eatonia #A-1	4	29	26	24	W3
H.P. Eatonia #A-2	9	29	26	24	W3
H.I. Pinkham #1	1	31	26	24	W3
P.H. Laporte #1	16	29	26	25	W3

APPENDIX B

Lithology of the Cores Examined

NOTE: The rock type in which these cores were classified is indicated in brackets.

P.H. Alsask #1

2659-2662 Rec. 2'6" (Deville "shale") White, angular chert fragments up to ½ inch in diameter, and brown siderite spherulites embedded in a dull-brown kaolin-illite matrix.

P.H. Cabri #1

3014-3019 Rec. 6" (Deville "conglomerate" ?) White chert fragments 3 inches in length, with trace of vein-like porosity and black oil stains.

Roy. Crystal #1

2631-2636 (Deville "shale") Siderite spherulites, with trace of small, badly weathered chert fragments embedded in green, red and brown waxy clays.

P.H. Cuthbert #1

3264-3274 (Deville "conglomerate" ?) Large "lumps" of badly weathered chert.

3272-3274 (Deville "conglomerate" ?) Large, unweathered chert fragments with trace of vein-like porosity.

P.H. Dewar #1

2717-2740 Rec. 19' (Deville "sand") Heavily oil stained semi-consolidated fine grain sand.

2740-2744 Rec. 3' (Deville "shale") Waxy grey clay with small pyrite crystals disseminated throughout.

H.P. Eatonia #A-1

2901-2910 (Deville "sand") Semi to unconsolidated, fine quartz grains, heavily oil stained. Thin shaley partings throughout.

2910-2920 (Deville "conglomerate" ?) Recovery consists of large, fresh to weathered chert fragments with trace of waxy shale lenses.

H.P. Eatonia #A-2

2871-2872 (Blairmore) Dark grey to black shale with trace of sand grains and small pyrite crystals.

2872-2877 (Deville "sand") Clear, rounded to sub-rounded quartz grains, with trace of fine grain chert fragments embedded in a white, powdery, kaolin-illite matrix.

2877-2882 (Deville "shale") Light brown to brown clay with trace of small chert fragments and siderite spherulites.

2884-2886 (Deville "conglomerate") White, angular chert fragments up to $\frac{1}{2}$ inch in diameter and chertified fossil remains, embedded in a grey calcareous matrix.

2888-(Rec. not known) (Deville "conglomerate") Angular chert fragments from $\frac{1}{4}$ to $\frac{1}{2}$ inch in diameter, with clear, fine grain quartz embedded in a white, powdery, kaolin-illite matrix.

2897-2897.5 Massive, brown, fine grain siderite.

2897.5-2898 (Deville "conglomerate") "Lumps" of partially weathered chert with considerable amounts of vein-like porosity.

2898-2918 (Deville "sand") Clear, rounded to sub-rounded, fine quartz grains, small, white, angular chert fragments and trace of siderite spherulites, embedded in a white, powdery, kaolin-illite

H.P. Eatonia #A-2 (cont'd.)

matrix. Iron carbonate staining in upper portion of the core.

H.P. Eatonia #B-1

2870-2876 (Deville "sand") Clear, rounded to sub-rounded, fine quartz grains embedded in part, in a powdery kaolin-illite matrix. Much of it is unconsolidated and heavily oil stained.

H.P. Eatonia #B-2

2847-2848 Rec. 1' (Blairmore) Dark siltstones and shales with considerable amounts of clear, rounded to sub-rounded, fine quartz grains.

2852-2878 Rec. 13' (Deville "sand") Clear, rounded to sub-rounded, fine quartz grains embedded in a white, powdery, kaolin-illite matrix.

2878-2880 Rec. 2' (Deville "sand") As above with iron carbonate staining.

2880-2908 (Deville "sand") Clear, rounded to sub-rounded, fine quartz grains, embedded in a white, powdery, kaolin-illite matrix, with iron carbonate staining in parts of the core.

P.H. Eastside #1

2750-2756 (Deville "shale") Badly weathered, angular, white chert fragments up to 1 inch in diameter, with trace of very fine quartz grains embedded in vari-coloured, waxy kaolin-illite clay.

H.P. Glidden #1

2670-2694 Rec. 24' (Blairmore) Salt and pepper, fine grain, calcareous sandstone.

2694-2695 Rec. 6" (Deville "sand") Clear, rounded to sub-

H.P. Glidden #1 (cont'd.)

rounded, fine quartz grains, with trace of fine grain chert. Oil stained.

2695-2702 Rec. 4' Interbedded sandstones as above, waxy clays and weathered chert fragments. Oil stained in part.

2702-2706 (Deville "shale") Grey, waxy kaolin-illite clay, with trace of siderite spherulites.

2706-2710 Rec. 2' (Deville "conglomerate") Clear, rounded to sub-rounded, fine quartz grains and small to large, white angular chert fragments. Heavily oil stained.

2710-2715 Rec. 1'6" Large, white, angular chert fragments, very hard and fresh, with some small cavities and veins. Oil stained.

H.P. Hoosier #1 (Lsd.13,S.11,T.31,R.28 W3)

2840-2850 Rec. 2' (Deville "conglomerate") Chert fragments up to 3 inches in diameter, with trace of fine quartz grains. Heavily oil stained.

2850-2853 Rec. 1'6" (Deville "conglomerate") Top 6 inches consists of oil stained chert fragments in a clay matrix, remainder of recovery consists of semi to unconsolidated oil saturated sand.

2853-2858 Chert fragments as above with trace of very hard quartzose sand.

H.P. Hoosier #3 (Lsd.16,S.10,T.31,R.28 W3)

2811-2825 Rec. 1'3" Large and small white angular chert fragments embedded in light green illite matrix. Some oil staining on exterior chert fragments.

2890-2892 White, unweathered chert fragments up to 1 inch in

H.P. Hoosier #3 (Lsd.16,S.10,T.31,R.28 W3) (cont'd.)

diameter, embedded in a white kaolin ? matrix.

2892-2909 Rec. 3' (Deville "conglomerate") White, angular chert fragments with trace of clear, rounded to sub-rounded, fine quartz grains embedded in a kaolin-illite matrix. Some oil staining.

P.H. Josephine #1

2967-2968 Rec. 3" White, angular chert fragments up to 1 inch in diameter with kaolin-like film on the outside, cemented in a calcareous matrix.

2968-2975 Rec. 4.5' (Deville "conglomerate") Large and small angular chert fragments with trace of clear, rounded to sub-rounded, fine quartz grains and siderite spherulites, embedded in a white, powdery, kaolin-illite matrix.

P.H. Laporte #1

3002-3006 (Sandy Deville "conglomerate") Clear, rounded to sub-rounded, fine quartz grains with angular, white chert fragments up to 1 inch in diameter, and trace of siderite spherulites, embedded in a white, powdery kaolin-illite matrix.

H.P. Madison #1

2798-2800 (Deville "sand") Clear, rounded to sub-rounded, fine quartz grains embedded in a well consolidated, white, powdery kaolin-illite matrix.

2800-2805 (Deville "sand") As above, with thin waxy shale partings.

2805-2808 (Deville "sand") As from 2798-2800.

2808-2811 Waxy, grey kaolin-illite clay.

2811-2814 (Deville "sand") As from 2798-2800.

H.P. Madison #1 (cont'd.)

2867-2873 White, angular chert fragments embedded in a green, waxy kaolin-illite clay.

Imp. Netherhill #10-33

2912-2917 (Deville "shale") White, angular, chert fragments up to ½ inch in diameter with weathered exterior, embedded in a waxy, green kaolin-illite matrix.

2962-2972 (Deville "shale") As above.

2973-2974 (Deville "shale") Large, partially weathered, white angular chert fragments.

Imp. Netherhill #11-17

2775-2778 (Blairmore) Dark grey shale.

2778-2785 (Blairmore) Salt and pepper, fine to medium grain calcareous sandstone.

2785-2835 (Deville "sand") Clear, rounded to sub-rounded, fine quartz grains, with trace of white, fine grain chert fragments, and siderite spherulites, embedded in a white powdery kaolin-illite matrix. Oil stained from 2830-2831.

2835-2835.3 (Deville "conglomerate") Large, very hard, fresh, white chert fragments, with veinlets of secondary calcite running through it.

2835.3-2841 (Deville "conglomerate") White, angular chert fragments, and quartz grains, embedded in a white, powdery kaolin-illite matrix.

2910-2915 (Deville "shale") White, angular, fresh chert fragments, embedded in a green, waxy kaolin-illite clay.

H.I. Pinkham #1

2918-2938 Rec. 4' (Blairmore) Fine to medium grain, salt and pepper sandstone with occasional thin, black shale partings.

2938-2942 Rec. 1'6" (Deville "conglomerate" ?) Large chert fragments fresh to weathered, stained in part with heavy oil.

2942-2942.3 (Deville "conglomerate") Chert fragments and chertified fossil remains embedded in calcite matrix.

2942.3-2958 Rec. 6' (Deville "conglomerate") Large, white, angular chert fragments, fresh to weathered with trace of vein-like porosity in part. Oil staining in blotches.

2958-2961 Rec. 2' (Deville "sand") Poorly sorted and patchy, consists of clear, rounded to sub-rounded, fine quartz grains, with chert fragments up to ½ inch in diameter, heavily oil stained.

2961-2966 Rec. 3'6" (Deville "shale") Small, white, angular, chert fragments, and siderite spherulites embedded in a waxy, grey kaolin-illite matrix. Sandy partings throughout.

Tide. Imp. Plato Crown #1

2688-2701 (Deville "sand") Clear, rounded to sub-rounded, fine quartz grains with trace of white, angular, fine grain chert embedded in a grey, powdery, kaolin-illite matrix.

2701-2709 Black, highly organic shale with considerable amounts of clear, rounded to sub-rounded, fine quartz grains throughout.

2709-2716 As above, with decrease in organic matter and increase in kaolin-illite, quartz and chert content.

2716-2727 (Deville "sand") Clear, rounded to sub-rounded, fine quartz grains with trace of siderite and fine grain, angular chert, embedded in a grey, powdery, kaolin-illite matrix.

Tide. Imp. Plato Crown #1 (cont'd.)

2727-2730 (Deville "sand") As above with trace of iron carbonate staining.

2730-2732 (Deville "sand") Quartz grains as above embedded in an iron carbonate matrix.

2732-2818 (Deville "sand") As from 2716-2727.

P.H. St. Eloi #1

2630-2640 (Deville "shale") Small, badly weathered, white chert fragments embedded in a waxy, green kaolin-illite matrix.

P.H. St. Florence #1

2569-2588 (Deville "shale") Fresh to weathered, white, angular chert fragments up to 1 inch in diameter, embedded in vari-coloured kaolin-illite clay.

2588-2593 (Sandy Deville "shale") As above, with considerable amounts of very fine quartz grains.

APPENDIX C

Electric Log Picks on Viking, Deville and Mississippian Tops

WELL	K.B.	VIK.	DEV.	MISS.
P.H. Alsask #1	2253	2260	2636	2676
P.H. Awde #1	2260	2242	2554	2628
P.H. Braeburn #1	2298	2244	2632	2667
P.H. Brock #1	2351	2345	2768	2857
P.H. Cabri #1	2317	2440	3002	3082
P.H. Coombe #1	2255	2372	2883*	3056
Roy. Crystal #1	2326	2290	2597	2713
Alminex Crystal #6-27	2325	2383	?	2846
Alminex Crystal #7-19	2284	2342	?	2797
Alminex Crystal #14-5	2316	2336	2736	2918
P.H. Cuthbert #1	2530	2600	3228	3322
Sohio D'Arcy #1	2354	2333?	2745	2869
P.H. Dewar #1	2305	2352	2710	2888
H.P. Dewar #15-34	2355	2370	2740	2785
P.H. Dungloe #1	2266	2249	2827?*	2854
P.H. Eastside #1	2454	2413	2730	2800
P.H. Eatonia #1	2444	2445	2900	3065
H.P. Eatonia #A-1	2407	2405	2878	N.D.E.
H.P. Eatonia #A-2	2385	2395	2861	N.D.E.
H.P. Eatonia #B-1	2423	2460	2858	N.D.E.
H.P. Eatonia #B-2	2384	2395	2850	N.D.E.
P.H. Eston #1	2242	2286	2798	2860
P.H. Eyre #1	2245	2306	2792	2845

Electric Log Picks on Viking, Deville and Mississippian Tops (cont'd.)

WELL	K.B.	VIK.	DEV.	MISS.
P.H. Fairdale #1	2129	2164	2660	2722
P.H. Fairmount #1	2282	2296	2671	2712
P.H. Flaxcombe #1	2468	2500?	2926	2951?
H.P. Glidden #1	2274	2264	2695	2774
P.H. Hoosier #1	2437	2450	2779	2858
H.P. Hoosier #3	2397	2416	2789	2983
P.H. Inglenook #1	2406	2390?	2800	2911
P.H. Josephine #1	2220	2294	2912	3045
P.H. Kiyiu #1	2302	2342	2750?	2865?
P.H. Laporte #1	2467	2512	2985	3115
P.H. Lemsford #1	2281	2328	2980*	3034
P.H. Leader #1	2112	2144	?	2704
P.H. Madison #1	2278	2292	2782	2877
P.H. Marengo #1	2461	2475	2878	2977
H.P. Marengo #2	2354	2353	2750	2843
H.P. Marengo #3	2499	2542	2964	3048
P.H. Mantario #1	2281	2355	2847	2900
P.H. McMorran #1	2377	2409	2818	2950
P.H. Merid #1	2214	2244	2670	2694
P.H. Netherhill #1	2291	2388	?	2830
Imp. Netherhill #10-13	2364	2361?	2780	2855
Imp. Netherhill #10-33	2391	2482	2895?	2975
Imp. Netherhill #11-17	2318	2327?	2785	2918
P.H. Newburg #2	2331	2346	2786	2859

Electric Log Picks on Viking, Deville and Mississippian Tops (cont'd.)

WELL	K.B.	VIK.	DEV.	MISS.
P.H. Normac #1	2253	2320	2863	2958
H.I. Pinkham #1	2445	2463	2938	3070
P.H. Pinkham #1	2520	2557	2979	3110
Tide. Imp. Plato Crown #1	2072	2120?	2688	2824
P.H. Prelate #1	2237	2223	2768?*	2784
P.H. Riverfront #1	2397	2440	2990*	3046
P.H. Ryerson #1	2353	2338	2642	2702
P.H. St. Eloi #1	2293	2263	2590	2682
P.H. St. Florence #1	2264	2215	2556	2642
P.H. Sandgren #1	2336	2335	2750	2868
P.H. Sceptre #1	2229	2249	?	2805
Sturgeon Smiley #3	2384	2388	2762	2894
P.H. Teo #1	2269	2246	2546	2660
P.H. Verendrye #1	2250	2272	2648	2701
P.H. Westerham #1	2156	2257	2780?*	2808

Note: K.B. denotes Kelly Bushing elevation.
N.D.E. denotes well not deep enough.
* denotes Deville overlain by Jurassic sediments.
* denotes Deville underlain by Jurassic sediments.

APPENDIX D

Drill Stem Tests Made in the Deville

P.H. Cabri #1

3006-3019 Open 60 minutes. Rec. 124' of mud cut slightly salty water. Rock type - Deville "sand" and Deville "conglomerate".

Alminex Crystal #14-5

2711-2761 Open 90 minutes. Rec. 110' of oil cut mud. Rock type - Blairmore and Deville "sand".

Roy. Crystal #1

2621-2631 Open 60 minutes. Rec. 30' of mud, tool partially plugged. Rock type - sandy Deville "shale".

2616-2636 Open 55 minutes. Rec. 150' of oil, 90' of oil cut mud, no water. Rock type - sandy Deville "shale".

2668-2683 No time. Rec. 270' of mud and salty oil cut water.

P.H. Cuthbert #1

3300-3319 Open 30 minutes. Rec. 60' of mud, 60' of water and mud, 60' sulphur water. Rock type - Deville "conglomerate" or Deville "shale".

P.H. Dewar #1

2722-2732 Open 90 minutes. Rec. 150' of gassy mud and oil. Rock type - Deville "sand".

2709-2722 Open 80 minutes, gas in 46 minutes, estimated at 5 Mcf. Rec. 190' gas cut oil, 50' gassy oil cut mud. Rock type - Deville "sand".

2733-2744 Open 6 minutes and packer gave way. Rec. 330' of oil cut mud. Rock type - Deville "sand".

<u>H.P. Dewar #15-34</u>

2731-2761 Open 60 minutes. Rec. 30' of clean heavy oil very slightly gas cut, 90' of mud cut oil, 90' of oil cut mud. Rock type - Deville "sand".

<u>P.H. Dungloe #1</u>

2828-2852 Open 45 minutes. Rec. 1022' of mud cut, slightly gas cut salt water, with few oil specks. Rock type - Deville "shale" ?

<u>H.P. Eatonia #B-1</u>

2854-2879 Open 60 minutes. Rec. 120' of gas and oil cut mud, no water. Rock type - Deville "sand".

<u>H.P. Eatonia #B-2</u>

2846-2893 Open 60 minutes. Rec. 6-12" heavy oil and 246' of 240' water cushion. Rock type - Deville "sand".

2893-2908 Misrun.

2890-2908 Misrun.

2907-2946 Rec. 260' of water (not salty), used 210' water cushion. Rock type - Deville "sand" and "conglomerate".

<u>H.P. Eatonia #1</u>

2923-2938 Open 60 minutes. Rec. 60' of heavily oil cut mud. Rock type - Deville "sand".

2923-2958 Open 50 minutes. Rec. 45' of clean oil, 255' of heavily oil cut mud. Rock type - Deville "sand".

2958-2978 Packer failed to hold. Rec. 135' of slightly oil cut mud. Rock type - largely Deville "sand".

2980-3036 Open 45 minutes. Rec. 200' of slightly oil cut mud. Rock type - Deville "conglomerate". Note - no salt water recovered.

<u>P.H. Flaxcombe #1</u>

2926-2948 Open 60 minutes. Rec. 90' of mud with occasional black oil specks. Rock type - Deville "shale".

<u>H.P. Glidden #1</u>

2684-2704 Open 15 minutes. Rec. 68' of heavily spotted mud. Rock type - Blairmore sands and Deville "sand".

2693-2715 Open 80 minutes. Rec. 10' of oil and mud emulsion, 140' of oil spotted mud, 180' of slightly spotted muddy gassy fresh water. Rock type - Deville "sand" with interbeds of Deville "shale".

<u>P.H. Hoosier #1 (S.11,T.31,R.28 W3)</u>

2775-2805 Open 60 minutes. Rec. 20' of very slightly gas cut mud.

2815-2840 Open 60 minutes. Rec. 145' of heavily oil and gas cut mud.

2813-2850 Open 90 minutes. Rec. 30' of oil cut gas and mud, 1146' of clean heavily gas cut heavy oil.

2849-2860 Open 30 minutes. Rec. 20' of mud. Rock type - in the above intervals is probably predominantly Deville "sand".

<u>P.H. Hoosier #3 (S.10,T.31,R.28 W3)</u>

2815-2855 Open 60 minutes. Rec. 210' of gassy oily water, and 60' of gassy oily mud, (used 210' of water cushion). Rock type - probably Deville "sand".

2821-2890 Open 120 minutes. Rec. 210' of gassy oily muddy water, (used 120' of water cushion). Rock type - probably Deville "sand".

P.H. Inglenook #1

2894-2920 Open 60 minutes. Rec. 75' of oil cut mud. Rock type - Deville "shale".

P.H. Josephine #1

2967-2975 Open 90 minutes. Rec. 75' of oil cut mud. Rock type - Deville "conglomerate" ?

P.H. Laporte #1

2995-3020 Open 50 minutes. Rec. 25' of slightly oil cut water. Rock type - Deville "conglomerate".

H.P. Madison #1

2778-2814 Open 60 minutes. Rec. 80' of mud, 1840' of salt water. Rock type - predominantly Deville "sand".

P.H. Marengo #1

2932-2947 Open 60 minutes, gas in 15 minutes. Rec. 30' of oil spotted mud, 1,050' of gassy clean black oil. Rock type - Deville "conglomerate" (indicated by E-Log).

2945-2958 Open 60 minutes. Rec. 70' of oil cut mud and 60' of slightly oil cut mud.

H.P. Marengo #3

2983-3015 Open 60 minutes. Rec. 125' of drilling fluid, heavily oil flecked at top. Rock type - Deville "conglomerate" ?

P.H. Merid #1

2786-2800 Open 30 minutes. Rec. 600' of drilling mud. Rock type - Deville "shale", core bleeding dark heavy oil.

Imp. Netherhill #11-17

2796-2814 Open 60 minutes. Rec. 185' of dead mud. Rock type - Deville "sand".

Imp. Netherhill #11-17 (cont'd.)

2885-2915 Open 60 minutes. Rec. 180' of mud, some oil flecks. Rock type - Deville "shale".

Imp. Netherhill #10-33

2857-2917 Open 50 minutes. Rec. 165' of slightly gassy mud. Rock type - Blairmore and Deville "shale".

P.H. Normac #1

2907-2924 Open 30 minutes. Rec. 330' of slightly salty water. Rock type - Deville "conglomerate" (indicated by E-Log).

H.I. Pinkham #1

2903-2966 Open 60 minutes. Rec. 60' of heavy oil cut mud. Rock type - Deville "sand" and Deville "conglomerate".

P.H. St. Eloi #1

2635-2645 Open 60 minutes. Rec. 380' of slightly salty water. Rock type - Deville "shale".

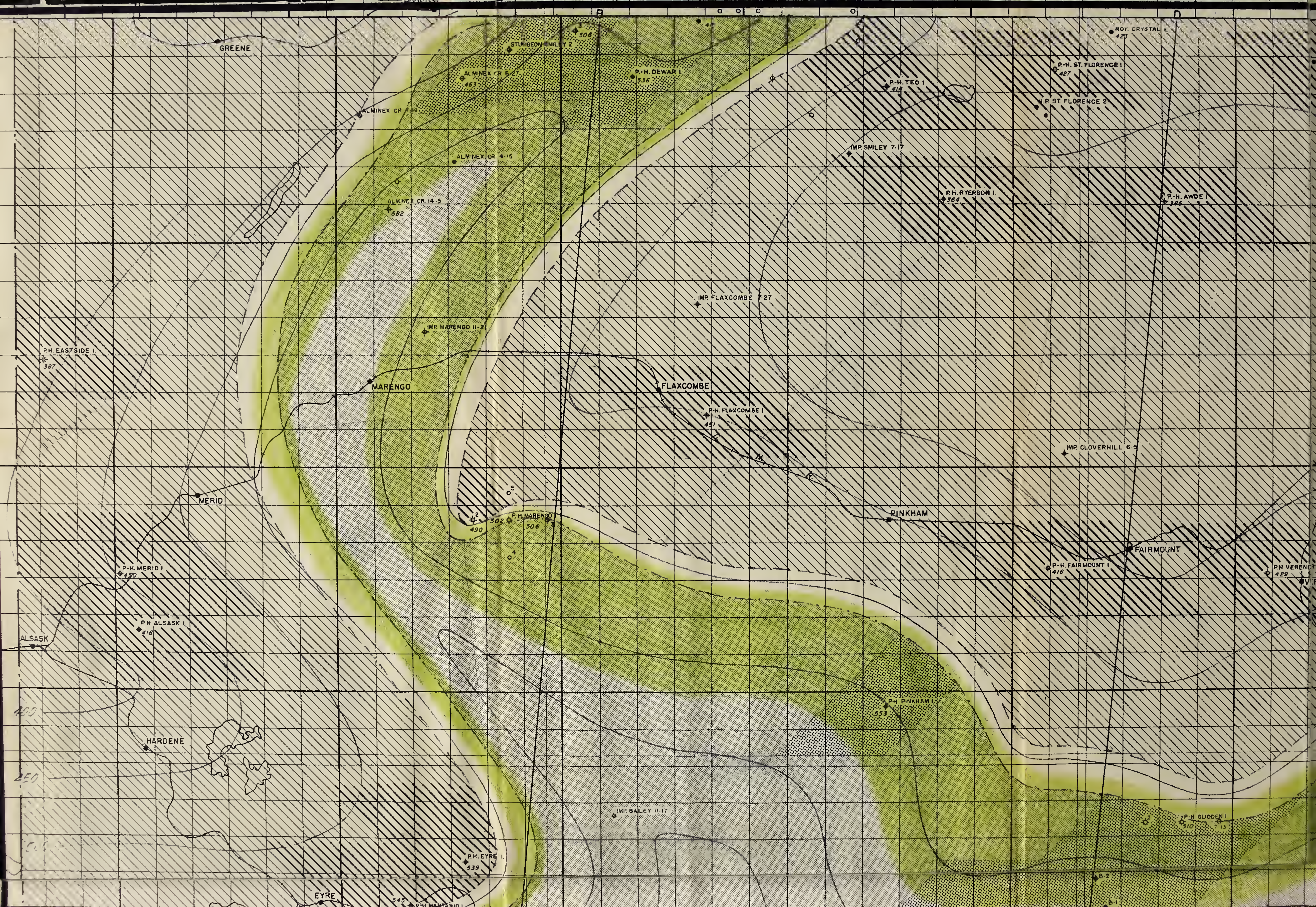
2652-2663 Open 60 minutes. Rec. 64' of slightly oil cut mud, tool plugged. Rock type - sandy Deville "shale".

2653-2663 Open 90 minutes. Rec. 300' of oil cut salt water and 300' of salt water. Rock type - sandy Deville "shale".

Sturgeon Smiley #3

2764-2800 Open 70 minutes. Rec. 180' of mud, top 30' oil flecked. Rock type - Deville "sand".

2824-2831 Open 120 minutes. Rec. 690' of salt water. Rock type - Deville "sand".


GREENE
STURGEON-SMILEY 2
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P-H. TEO 1
414
P-H. ST. FLORENCE 1
427
ROY. CRYSTAL 1
423
IMP. SMILEY 7-17
P-H. RYERSON 1
364
P-H. AWDE 1
386
IMP. FLAXCOMBE 7-27
IMP. MARENGO 11-2
P.H. EASTSIDE 1
387
MARENGO
FLAXCOMBE
P-H. FLAXCOMBE 1
451
IMP. CLOVERHILL 6-5
MERID
PINKHAM
FAIRMOUNT
P.H. MARENGO
490
502
506
P-H. MERID 1
P-H. FAIRMOUNT 1
416
429
P.H. ALSASK 1
416
ALSASK
P-H. PINKHAM 1
553
HARDENE
400
450
IMP. BAILEY 11-17
P-H. GLIDDEN 1
510
P-H. EYRE 1
539
EYRE

P-H. ST. ELOI 1
419
P.H. BRAEBURN 1
SOC. HUTFORD 28-10
Tp.30
523
P-H. KIYIU 1
P.H. DENEHURST 1
433
P.-H. SAGE 1
400
P.-H. NETH. 1
430
SOC. NETHERHILL 28-10
SOH. FISKE 1
Tp.29
IMP. NETH. 10-13-29-20
494
D'ARCY STATION
450
KINDERSLEY
BEADLE
NETHERHILL
IMP. BR. 6-5
400
IMP. NETHERHILL 10-33-28-21
493
IMP. BR. 7-31
BROCK
P. BROCK
IMP. BR. 7-25
IMP. BR. 6-19
IMP. BR. 11-17
SOH. D'ARCY
Tp.28
P.H. VERENDRYE 1
429
VERENDRYE
450
P.-H. McMORRAN 1
P.-H. NEWBURG 1
P.-H. INGLENOOK
INGLENOOK
500
P.H. SANDGREN 1
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MC MORRAN
PENKILL
Tp.27
SANDGREN
P.H. GLIDDEN 1
IMP. NETH. 11-17-27-21
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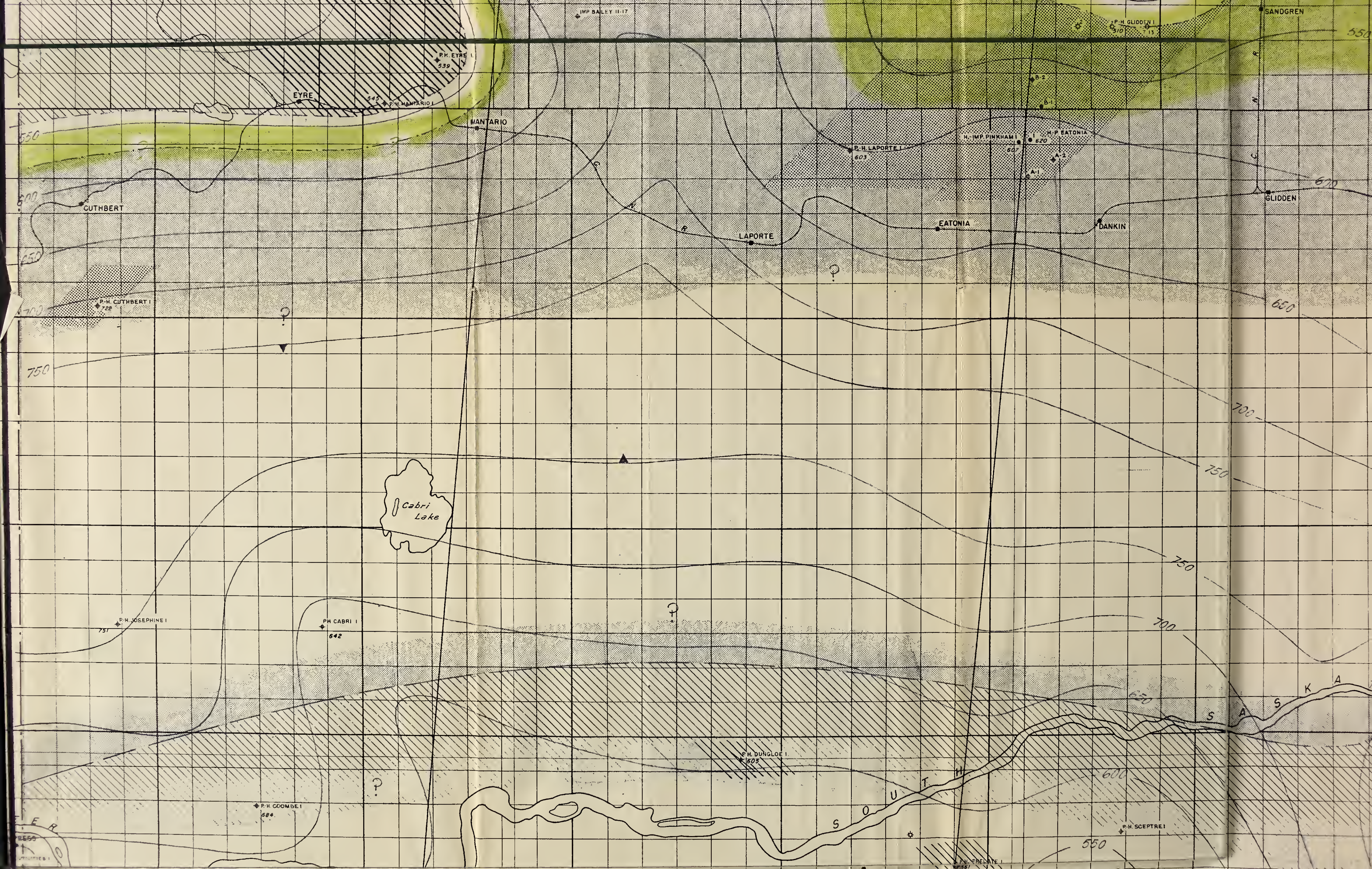

IMP BAILEY 11-17
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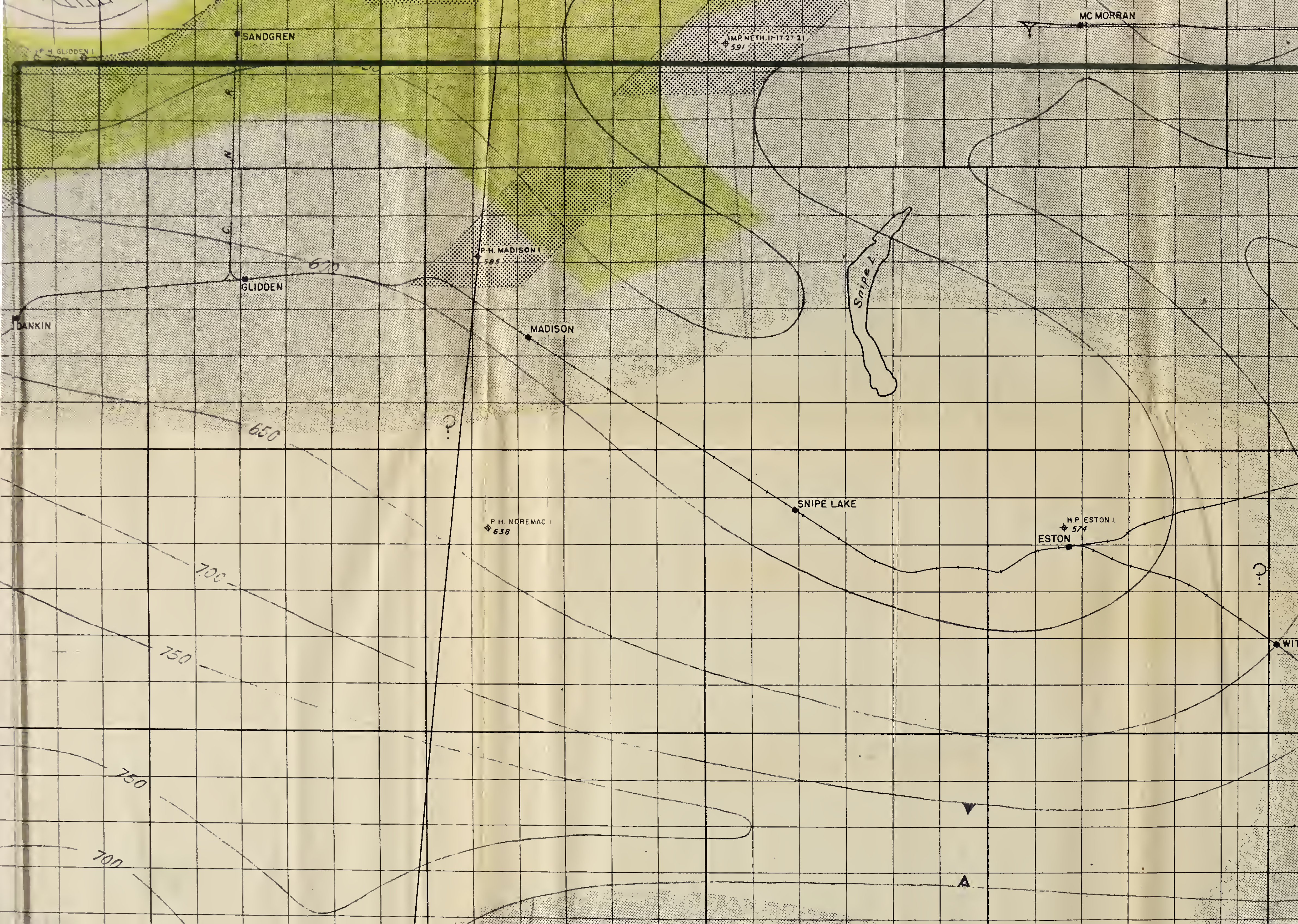
EYRE
545
P-H MANTARIO 1
MANTARIO
B-2
B-1
P-H LAPORTE 1
603
H. IMP. PINKHAM 1
607
620
H-P EATONIA
A-2
A-1
GLIDDEN
CUTHBERT
EATONIA
LAPORTE
DANKIN
P-H CUTHBERT 1
722
550
600
650
700
750
Cabri Lake
P-H JOSEPHINE 1
751
PH CABRI 1
642
P.H. DUNGLOE 1
605
P-H COOMBE 1
684
P-H SCEPTRE 1
S O U T H
S A S K A



SANDGREN
P.H. GLIDDEN I
IMP. NETH. 11-17-27-21
591
MC MORRAN
GLIDDEN
DANKIN
P.H. MADISON I
585
670
MADISON
Snipe L.
650
SNIPE LAKE
P.H. NOREMAC I
638
H.P. ESTON I.
574
ESTON
700
750
750
700

PLATE – II

KINDERSLEY AREA

SASKATCHEWAN

VIKING – MISSISSIPPIAN ISOPACH

(ASSUMING VIKING HORIZONTAL)

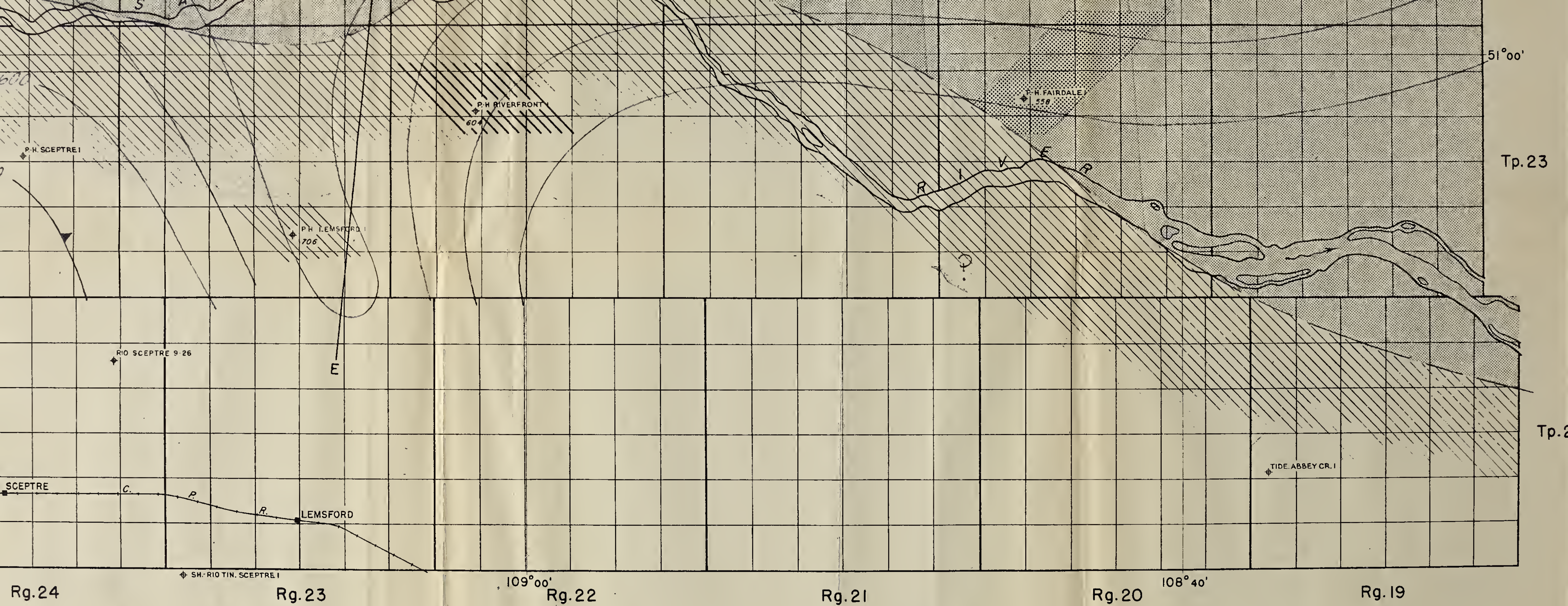
AND FACIES OF DEVILLE FORMATION

SCALE: 1 in. - 2 mls.

2 MLS. 1 0 2 4 6 MLS.

○ Location
● Oil Producer
⊙ Drilling
☼ Gas Producer
ф Standing
✦ Abandoned

SASKOIL LEADER I



AREA

EWAN

ISOPACH

ONTAL)

FORMATION

4 6 MLS.

LEGEND

(for further explanation see page: 20-24-32)

Viking - Mississippian Isopach

Jurassic Pinch-out

Inferred Pinch-out of Deville "Congl."

Inferred Pinch-out of Deville "Sand"

LEGEND

(for Deville facies)

Areas of known Deville "shale" (underlain by Mississippian)

Areas of inferred Deville "shale" (underlain by Mississippian)

Areas of known Deville "sand"

Areas of inferred Deville "sand"

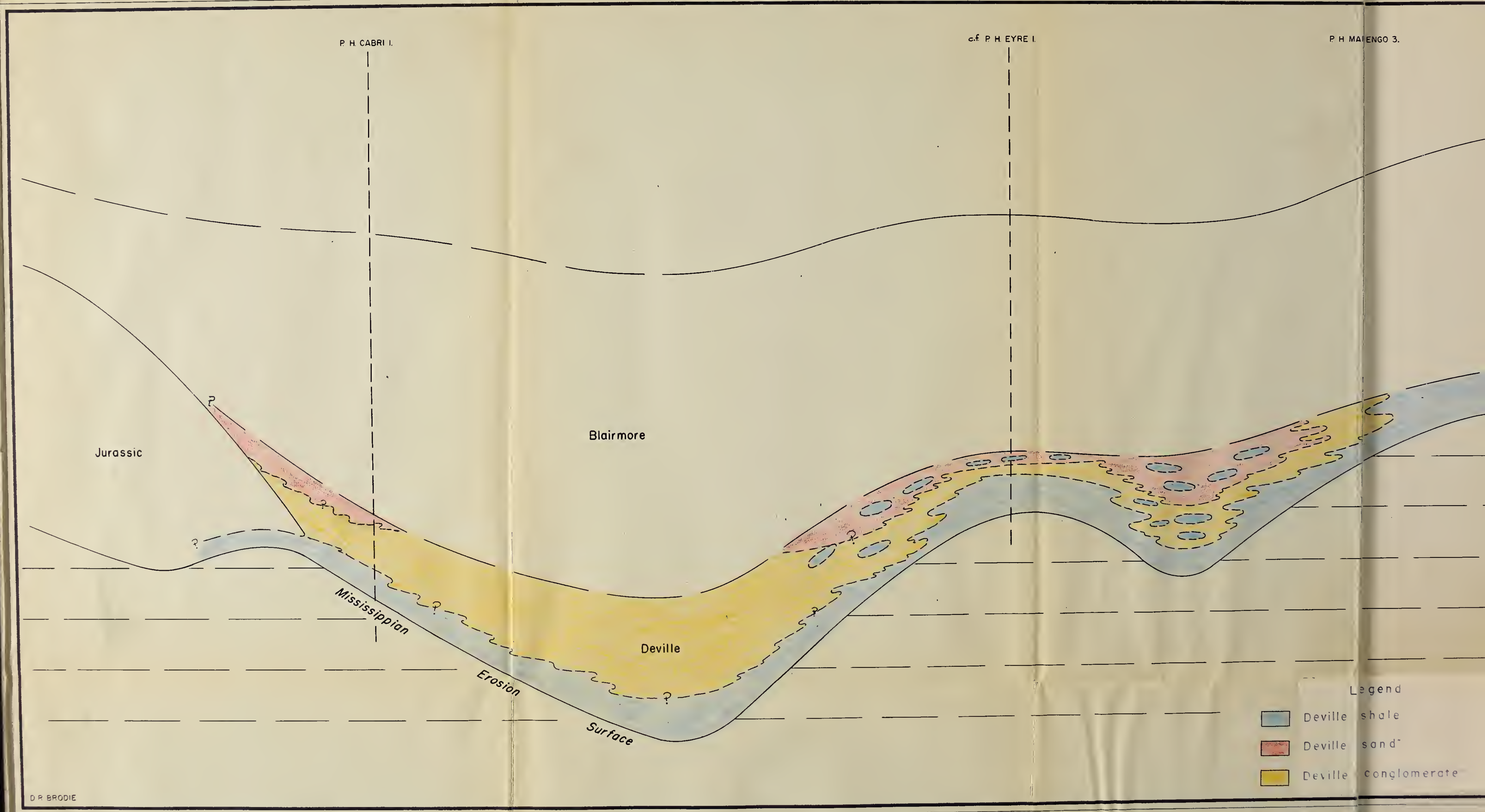
This area underlain by Deville "conglomerate", which is in turn underlain (in part at least) by Deville "shale"

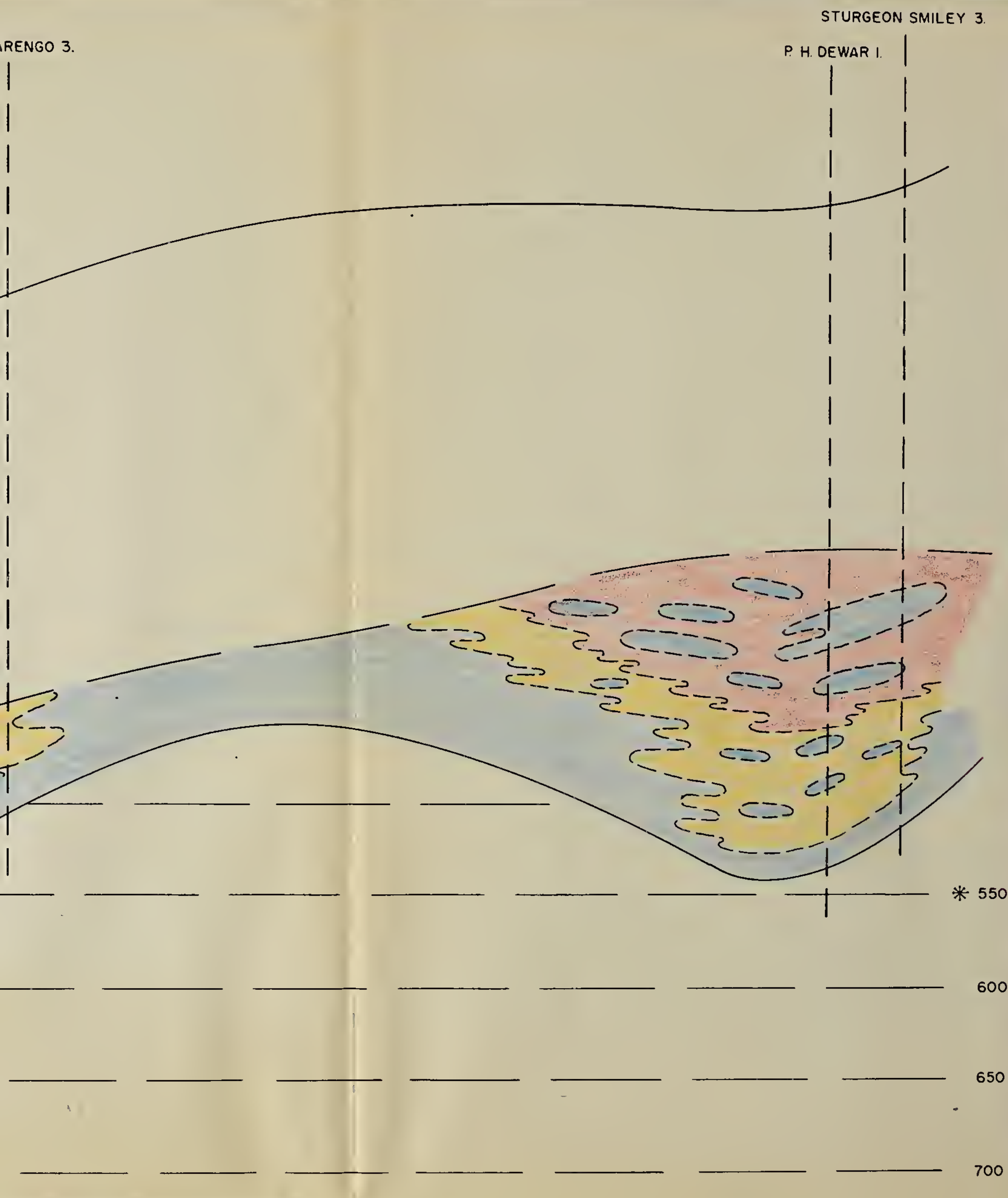
Blank areas north of Jurassic pinch-out represents Deville "conglomerate" underlain (in part at least) by Deville "shale"— section largely inferred

Blank areas south of Jurassic pinch-out represent Jurassic.

Recommended areas for further exploration

TIDE CABRI CR. I


P. H. CABRI I.
c.f. P. H. EYRE I.
P. H. MARENGO 3.
Jurassic
Blairmore
Deville
Mississippian
Erosion
Surface
Legend
Deville shale
Deville "sand"
Deville conglomerate
D. R. BRODIE



egend

"shale"

"sand"

"conglomerate"

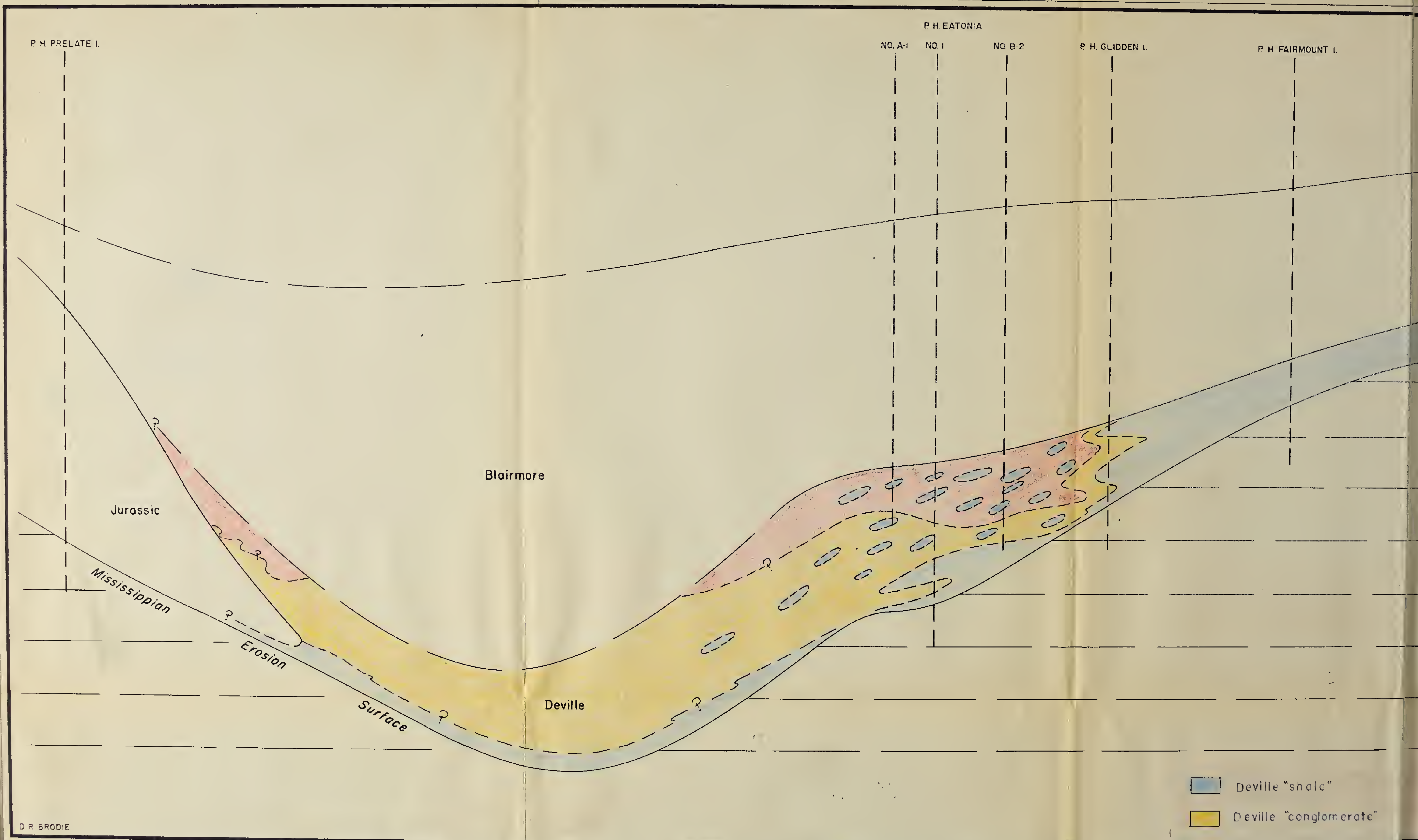
PLATE - III

CROSS SECTION "A-B"

(IN PART INFERRED SEE PAGE:24-32)

Horizontal Scale: I inch - 2 miles
Vertical Scale: I inch - 75 feet

✻ Viking - Mississippian Isopach Values



P. H. EATONIA
P. H. PRELATE I.
NO. A-1
NO. 1
NO. B-2
P. H. GLIDDEN I.
P. H. FAIRMOUNT I.
Blairmore
Jurassic
Mississippian
Erosion
Surface
Deville
Deville "shale"
Deville "conglomerate"
D. R. BRODIE

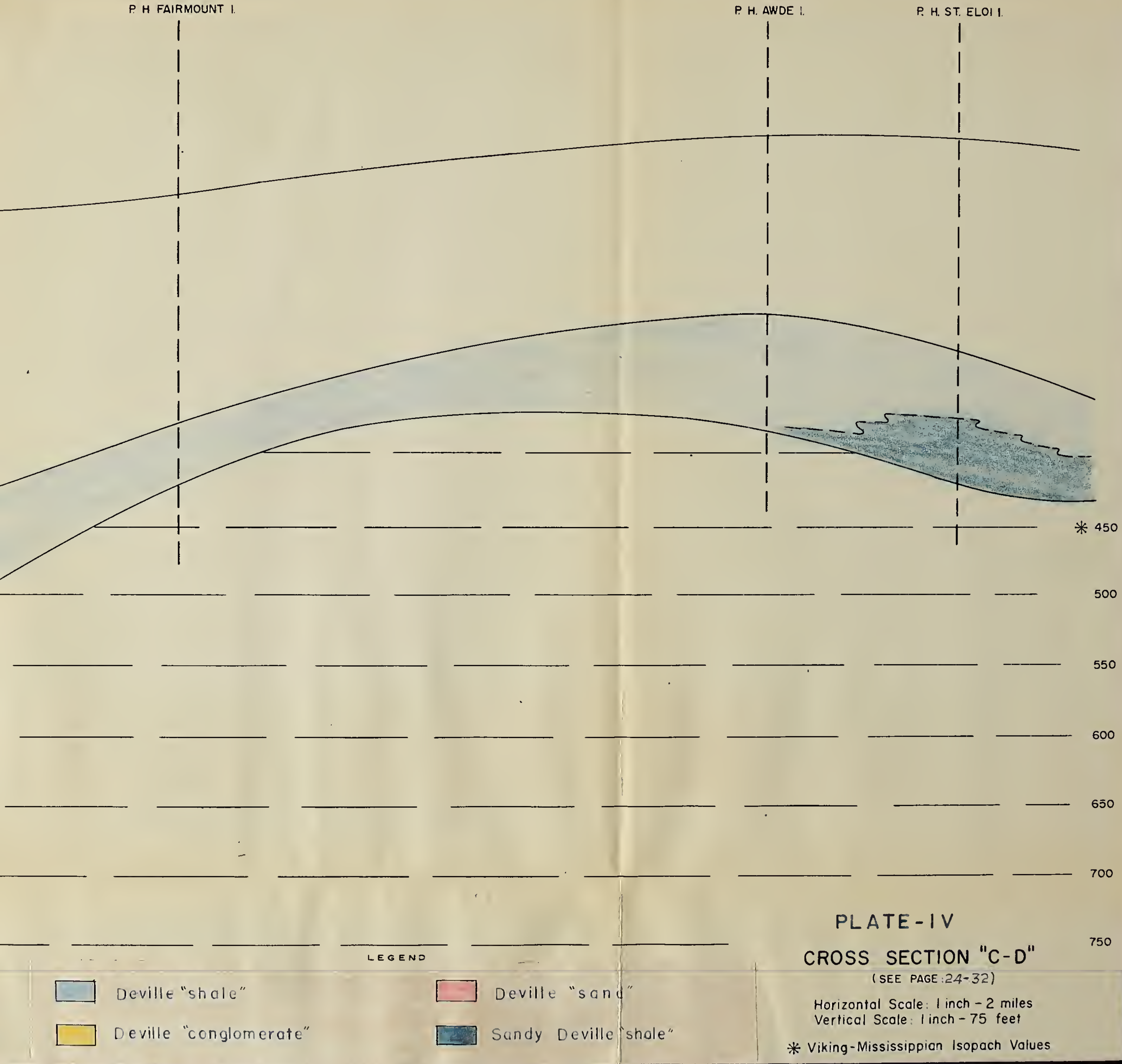


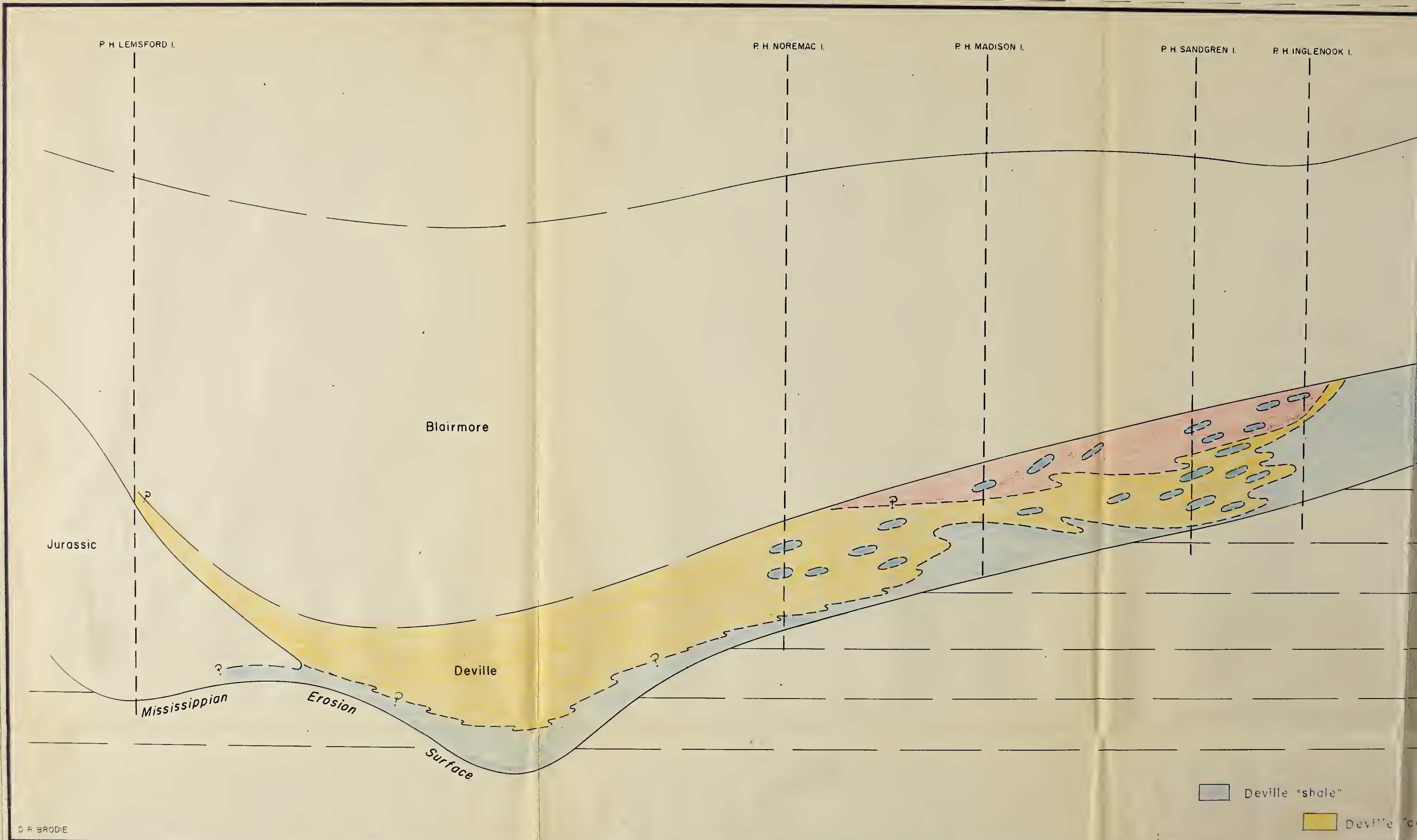
PLATE-IV

CROSS SECTION "C-D"

(SEE PAGE: 24-32)

Horizontal Scale: 1 inch - 2 miles
Vertical Scale: 1 inch - 75 feet

✻ Viking-Mississippian Isopach Values


P. H. LEMSFORD I.
P. H. NOREMAC I.
P. H. MADISON I.
P. H. SANDGREN I.
P. H. INGLENOOK I.
Blairmore
Jurassic
Deville
Mississippian
Erosion
Surface
Deville "shale"
D R BRODIE

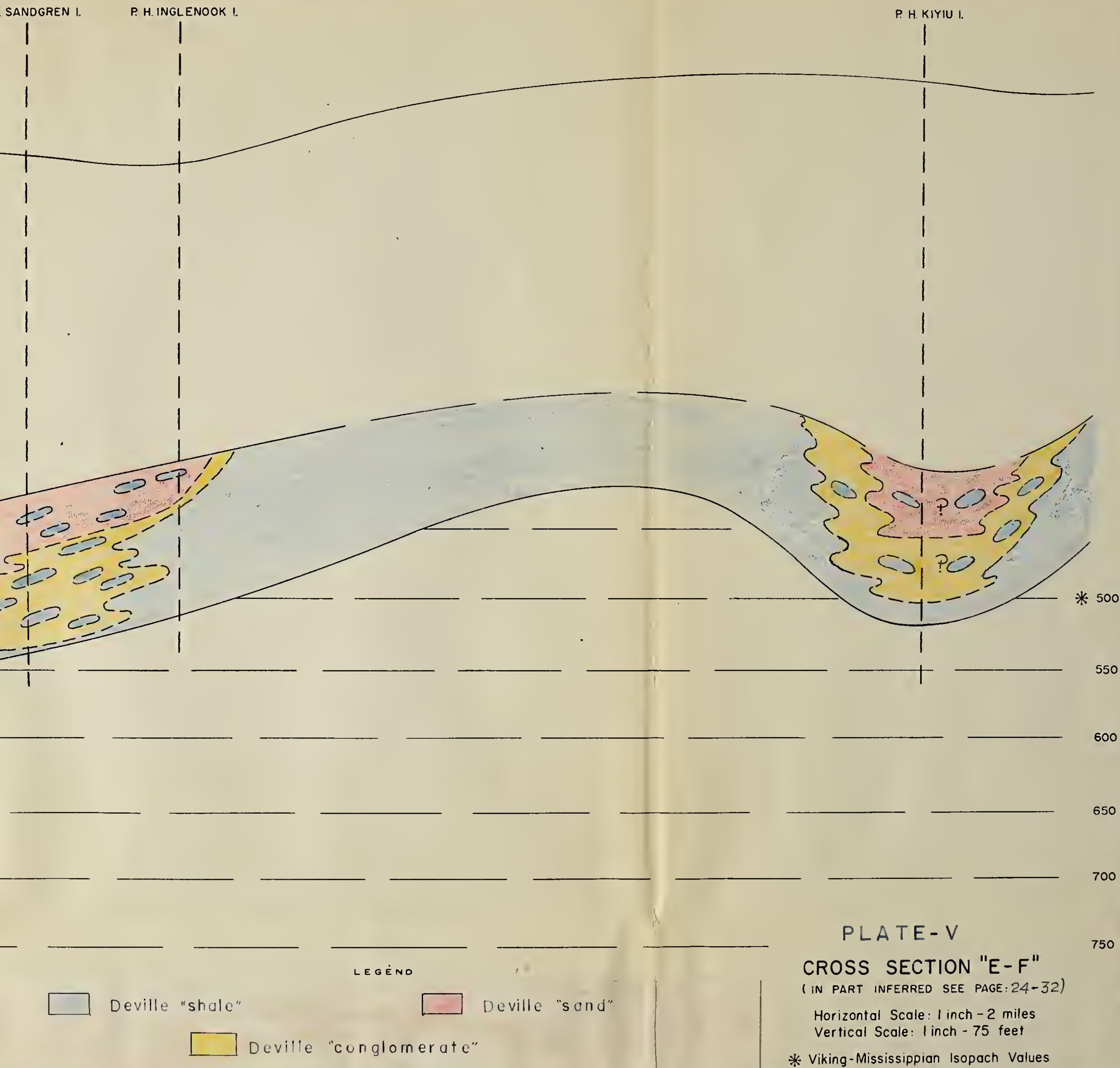


PLATE-V

CROSS SECTION "E-F"

(IN PART INFERRED SEE PAGE: 24-32)